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PROFITS & PRINCIPLES. **IS THERE A CHOICE**

Renewables

products and markets

Renewables

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Editor
Mahesh Vipradas

Foreword
R K Pachauri

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Foreword

Wide acceptance in the society regarding the interlinkages among environment, poverty, and sustainable development forces our attention to technological solutions that address the needs of today without producing any negative externalities. It is in this regard that RETs (renewable energy technologies) have gained immense popularity.

Recognizing the importance of rural development in ensuring equity in the pattern of growth, RETs today are being used to address a wide range of issues for the rural areas. The attractiveness of RETs such as wind, solar, and biomass lies primarily in their abundance. Since a large number of rural communities consume very low quantities of electricity, extending electricity grids may be less economically viable than other decentralized forms of energy generation using local renewable resources. Decentralized energy production and distribution may also provide rural development opportunities and encourage local institutions to manage their own energy needs. Photovoltaics, solar lanterns, and solar home lighting systems have been a few of the technological interventions in this regard.

Inefficient use of biomass in traditional devices not only has health effects but serious environmental effects both at the local and global levels as well. This, coupled with the fast-reducing resource base of the poor, leads to consideration of technologies addressing energy-efficient utilization of biomass. Solutions of this nature open up immense possibilities for the poor gaining access to a clean fuel, without putting pressure on the natural resources around them. It is in this regard that improved cookstoves, biogas plants, and solar cookers have gained popularity.

However, technologies and installations have to be provided with due regard to replication and integration into long-term development strategies. This, in turn, necessitates the spread of these technologies through market channels requiring the provision of a maintenance and after-sales servicing infrastructure.

Evolution of a viable renewable energy product involves careful study and resolution of the various conflicts arising out of concerns and requirements of the user, funding agency, design engineer, and product developers. R&D efforts have resulted in a wide variety of techno-economically feasible RETs, which have opened up possibilities for a quantum jump in the further spread of renewable energy use. The understanding of the complete product and market development process is essential for proper allocation of resources in the development of any renewable energy product. Further, regular assessments of technology status and resource, demonstration of key technologies, and market-pull mechanisms are required.

India has adequate technical competence to become a world leader in the development of and use of RETs. India could become the leader due to economies of scale in large volume production for a potential market of the size that India would provide.

The collection of articles in this book, the edited version of presentations at the conference *Renewables 21: Products and Markets*, address precisely these issues. They cover the issues and concerns related to product and market development in renewable energy (biomass and waste utilization, wind energy, solar cookers, photovoltaic construction elements, solar pond, and biogas); challenges of rural marketing; rural entrepreneurship development; and renewable energy commercialization. The coverage of the experiences of the IDE, the Swiss Agency for Development and Cooperation, and Greek Solar Industry Association lends an international perspective on the rural and renewable energy scenario. It is hoped that this book would be useful to all those seriously engaged in renewable energy promotion activities at academic as well as practical levels.

R K Pachauri
Director, TERI

Preface

The focus of this collection of papers, which were presented at the conference *Renewables 21: Products and Markets*, is product and market development in renewables. The papers deal mainly with the efforts for promoting RETs (renewable energy technologies) in three main segments: rural, decentralized and commercial, and grid connected. The papers also deal with domestic and industrial sectors in rural and decentralized and commercial applications, thereby covering the whole range of RETs. The topics include product conceptualization, prototype development to various facilitative measures for renewable energy technologies, and the process of product and market development and their interdependence.

Although the individual papers focus on different technologies and different interventions for better penetration of renewables, they constitute various steps in the process of product and market development. More importantly, the papers are based on actual experiences in product or market development, further enhancing the importance of these processes. The papers also bring out the underlying issue related to financing in the renewable energy sector. Thus, through the information reported in various papers, this book helps understand the key issues and roles of various institutions at each step of product and market development. The understanding of this complex process will provide valuable inputs for the planning and policy-making of renewables.

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Special mention must be made of the indispensable guidance and support provided by Dr R K Pachauri, Director, TERI.

Product and market development process in renewables

Mahesh Vipradas and Ajay Mathur

Introduction

As a result of various R&D initiatives and efforts, a wide variety of techno-economically feasible RETs (renewable energy technologies) are now available. Different programmes consisting of promotional efforts and policies are also in place to create a market for these technologies. All these programmes, a majority of which are government-led, have resulted in some success in creating markets for many of the RETs. However, the commercialization and market penetration of renewables in the overall energy sector (worldwide) is still very low. The contribution of renewables to total power generation is as low as one to two per cent. Though the strategies for promotion are different for the three broad categories of renewables – rural, urban, and grid-connected – the cross-cutting issues among these categories are mainly related to product and market development. Evaluations indicate that in the stages from R&D to successful commercialization of renewables, the identification and development of appropriate products is a weak link. Also, marketing strategies have yet to acquire the sophistication required for commercial products, and back-up services have not reached the optimal level essential for effective market penetration. Further, the important aspect of modifications in the products based on market feedback has been neglected greatly.

Various organizations, including the government, multilateral and bilateral agencies, and NGOs (non-governmental organizations), have made several efforts to promote renewable energy products. These efforts cover an entire range of promotional activities for RETs—from marketing of solar lanterns in rural areas by IDE at one end of the spectrum to adoption of NFFO (non-fossil fuel obligations) in the UK at the other (read *Challenges of rural marketing in*

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India: IDE India's experience by Minhazz Majumdar and Thomas Hemphill, in this volume, pp. 7–22). These efforts were, and continue to be, focused on specific issues like product development, micro-credit, and development of maintenance network (read *Development and implementation of the non-fossil fuel obligation in the UK* by Garry M Staunton, in this volume, pp. 73–82). Based on the lessons drawn from these efforts at product development and market creation in the entire spectrum of RETs, a complete procedure of product development – from conceptualization to commercialization – emerges. During each step, from conceptualization to commercialization, the availability of resources is of vital importance. The returns on the investment in the development of renewable products are usually at a low rate, spread over a longer period and, in most cases, indirect. Thus, the availability and appropriate allocation of resources to achieve the ultimate objective of wider penetration of RETs is the key factor that affects and decides the future of this sector. The aim of this paper is to discuss the various steps and major issues involved in this process and their importance along with the key issue of financing.

Development–commercialization of products

The process of product development to commercialization has three distinct phases: identification and conceptualization of product from the existing core technology, product development, and market development. Product development and market development are

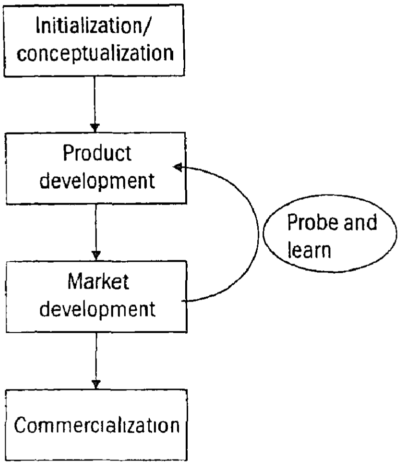

Figure 1 Framework of product and market development

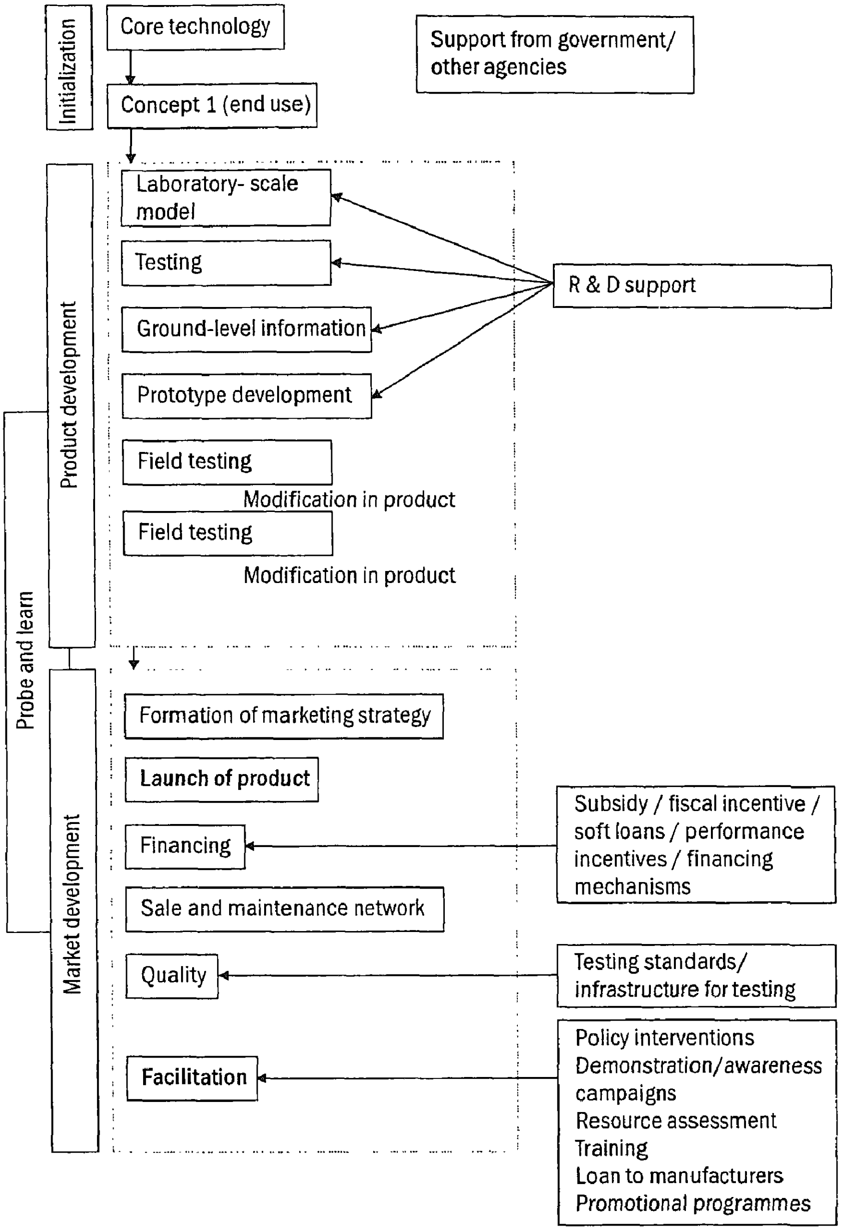

Figure 2 Product and market development process

closely interlinked by probe and learn, a process of continual feedback and modifications in the product or a market development strategy based on feedback (Figure 1). Each phase involves a number of steps, governed by different factors; Figure 2 explains each phase in detail.

Conceptualization

The concept of a product is based on understanding the technology and information about the needs of specific user groups. There could be more than one product based on one technology, e.g. photovoltaic (PV) pumps, home lighting systems, lanterns. The initiation usually comes from experts working on the technology and through interaction with users. In some cases, the government agency or other organization feels the need for a specific product and initiates product development (read *Issues and concerns related to product development in renewable energy* by V V N Kishore, in this volume, pp. 63–72).

Product development

After conceptualization, the next step is to make a laboratory-scale model that can meet the users' needs and test it. A ground-level survey to assess the market for the product and the needs of the user is essential before initiating product development. Based on the laboratory-scale model and the results of the ground-level survey, a prototype is developed for field testing.

The key issues in this phase are assessing the economic viability of the product and the potential market, finding an agency which can support product development and completing the prototype development on time and without compromising on the quality. The ground-level survey helps in assessing the viability of the product and its potential market.

Product development is mainly supported by the government. The long-term support for the product development is essential as the time required for any technology to move from a concept to a marketable product is 5–8 years. This underlines the importance of resource allocation, and the vision to do so, for different technologies in view of the limited resources available. There is a need to use policies, if possible, to leverage in private resources for R&D. Bilateral and multilateral agencies, and industry do not usually support product development.

Probe and learn

This is a crucial link between the product and its market. It is a process of receiving feedback from the user / market. Initially, the focus is more on product development through modifications in the product based on the feedback from users. In the later stages, the inputs are used for market development by devising facilitative measures

The prototype is modified by incorporating the feedback from field testing. The field tests are aimed at checking the acceptability of the product by the actual user. It also tests the operational problems faced by the user. Field tests with persistent follow-up of users for feedback and subsequent modifications translate the prototype into a product, which can be marketed. This step may take more time than prototype development. Once the product is launched, feedback from the market guides the marketing strategy and identifies other interventions required. These include modification in the marketing strategy, financing, and other promotional efforts.

This crucial link gets comparatively less attention. Once the prototype is ready, the researcher starts losing interest. Further, the funding (mainly by the government) usually ends at prototype development or laboratory testing and starts directly at system financing, thereby neglecting this important step which connects products to markets.

Market development

Market development is essential especially in the case of renewables as a new product with a new technology is being offered. Market development involves three major components—financing, marketing and after-sales network, and market facilitation.

The higher initial cost of renewable energy products compared with conventional products for the same end-use, calls for system/project financing. Capital subsidy is offered in the beginning to create a demand in the market and confidence in the product. With the development of the market, subsidies are gradually replaced by other mechanisms such as soft loans with fiscal incentives and preferential tariff. The financing mechanism is closely linked to the type of product and the target user group; for example, the micro-credit mechanism for marketing PV home systems in rural areas, or the proposal of higher tariffs for power from renewables in Electricity Bill 2000 in India. The GHG (greenhouse gas) abatement mechanisms such as CDM (clean development mechanism) and GEF (Global Environment Facility) and concepts such as third-party financing and energy service company are the upcoming avenues for financing renewable energy products.

Development of a marketing and maintenance network is the next step in market development. This step is more significant for products with markets in the rural, commercial, and industrial sectors. Ready availability of the product with assured after-sales services is essential for market development. Development and support to entrepreneurs who can take up this task is an effective way of market development especially in rural areas (read *Developing rural entrepreneurship to promote photovoltaic systems* by Harish Hande, in this volume, pp. 29–31).

Market development involves a number of facilitative measures from all the agencies involved. In the initial stages, the product is promoted through demonstrations along with creation of awareness. After the initial market creation, continuous policy-level support in terms of various incentives makes the product sustainable. Quality assurance is achieved through development of testing standards and infrastructure for testing and certification. Training of technicians for proper installation, and of entrepreneurs is an essential component for market penetration.

Market development is supported by the government in the initial stages. With the initial creation of demand, other agencies (multilateral and bilateral agencies, industries, and NGOs) take over the task of market development. The government still plays the role of a facilitator in this process. The climate change initiatives would act as a catalyst in the process of market development in renewables with the development of new financing mechanisms. This could further leverage support for appropriate product development.

This is the overall process of development of a renewable energy product. Not all products start from Step 1; in many cases, existing products in other areas/countries are adapted to suit local conditions and then marketed, i.e. they enter at a different stage of these product and market development process. Further, the market development approaches differ significantly for different products depending upon the market and end-use.

Conclusions

The understanding of the complete product and market development process is essential for proper allocation of resources, including time, in the development of any renewable energy product. Further, the entire 'probe and learn' phase, which is a link between the product and market, is crucial and usually gets less attention resulting in more laboratory-scale prototypes and very few commercialized products.

Challenges of rural marketing in India: IDE India's experience

Minhazz Majumdar and Thomas Hemphill

Introduction

In developing countries, introduction of a simple technology can mean the difference between survival and starvation. Taking cognizance of this basic fact, the IDE (International Development Enterprises), a non-profit organization, began with the mission of identifying, developing, and disseminating affordable, appropriate, and environmentally sustainable technologies to small and marginal farm families in the developing world. The IDE's innovation, however, lies in the fact that it has chosen a route of marketing to reach out to the rural poor.

The IDE India has primarily been working with appropriate irrigation technologies and has recently ventured into rural marketing of renewable energy technologies. This paper looks at the IDE's market-oriented development strategy, with particular focus on the IDE India's experience in promoting the treadle pump in the rural market. The various promotion and marketing approaches tried and tested with the treadle pump could serve, with some modification, as a guide or model in marketing other appropriate technologies, including renewable energy technologies.

With the treadle pump, the IDE India has been able to successfully use donor funds to establish a penetrative delivery mechanism – a commercial marketing channel – for products specifically meant to ensure socio-economic development of poor farmers. The IDE India is today an acknowledged expert in rural mass marketing, and the treadle pump programme is a major success in terms of marketing innovative technology to poor farmers.

IDE and the uniqueness of IDE's model

The IDE was founded in 1981 and registered in USA, Canada, and the UK with institutional headquarters in Denver, Colorado (USA). Today, the IDE is a leading authority on the development and mass

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IDE India, C5/43, Safdarjung Development Area, New Delhi – 110016, India

dissemination of appropriate technologies in developing countries through the private sector and NGOs (non-government organizations). The IDE India was established in 1991 and is presently working in select districts of Andhra Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Rajasthan, Tripura, Uttar Pradesh, and West Bengal.

Socio-economic development of small and marginal farmers can be accomplished by viewing them as customers rather than as beneficiaries or recipients of charity. In other words, the IDE firmly believes that a farmer, however marginalized, has the capability and dignity to purchase an affordable range of products and, through their use, increase his earnings by more than 100% within one cropping season. Developmental efforts include enhancing simultaneously the economic status of village-based entrepreneurs such as manufacturers, distributors, agri-input dealers, and *mistries* (self-employed mechanics). This can be achieved by providing them with business opportunities through delivering the IDE's products and providing after-sales service and agronomic inputs to small farmers.

The IDE's commitment and mandate is not limited to mere delivery of technology. There is an emphasis on dissemination of affordable technologies and, more importantly, related services, both of which are crucial for poverty alleviation and enhancement of livelihood. The goal of a responsible NGO is to adopt a sustainable development paradigm that is replicable by other development agencies. Most government agencies and traditional NGOs treat small-scale farmers as beneficiaries of others' largesse, and their programmes last for only as long as funding is available. Also, such development schemes allow farmers no control over the system. The IDE, on the other hand, supports local manufacture, distribution, and marketing of appropriate technologies in developing countries and uses donor funds to create village-based entrepreneurs to stimulate a sustainable and free market.

Creating commercial marketing channels and a network of like-minded NGOs for the IDE's products accomplishes two important objectives.

1 A system that is commercially viable and can therefore sustain itself for as long as there is a market demand for the products—like any other channel.

2 As the farmer is a customer, manufacturers, distributors, and dealers respond to the farmers' collective market demands.

The ongoing demand for the products ensures their continuing availability through the marketing channel. Through exercising purchasing power, the farmer (unlike a traditional NGO beneficiary) has a degree of control over the access to required products.

The process of identifying, developing, and disseminating affordable, appropriate, and environmentally sustainable technologies has been very carefully worked out. The IDE does not invent any of the products it promotes; rather, it selects an existing product or technology that is of significance to its target group (small and marginal farm families) and then adapts or upgrades it. As a part of this process, the product is extensively field-tested and the farmers' feedback sought to improve the product. This is followed by a test-marketing phase during which the price, margins, viability of the product, etc. are examined. Subsequently, the product is considered ready for large-scale mass marketing or commercialization. These processes constitute the IDE's core PIC (product identification and commercialization) strategy.

In a nutshell, the IDE's model for sustainable development is that of bridging gaps at various levels

- *Bridging the gap between irrigation technological inventions in research institutions and their adaptations to suit the needs of small and marginal farmers* the IDE identifies such technological innovations from across the world and modifies them to cater to the needs and affordability of small farmers.
- *Bridging the gap between availability of low-cost technologies and awareness about them by small farmers based in remote villages* the IDE employs innovative promotional techniques to generate awareness about the IDE's products among the marginal farmers.
- *Bridging the gap between demand for the IDE's products and their supply to small farmers in rural areas* the IDE nurtures the commercial marketing channel and the NGO network to ensure that its products reach small farmers in the remotest corners of the country.

IDE India's products

Affordable irrigation water is the greatest need of India's small and marginal farmers and the IDE India has concentrated on developing appropriate, low-cost, environment-friendly irrigation systems. These systems will help farmers make their land more productive and achieve long-term socio-economic improvement. In areas with a high water table, the IDE promotes the use of a manually operated water-lifting device called the treadle pump (also known as pedal pump). In semi-arid areas, the IDE has adapted, developed, and introduced AMIT (affordable micro irrigation technologies) in the form of kits such as a bucket kit, drum kit, micro sprinkler kit, and an overhead sprinkler kit.

The treadle pump

Originally developed in Bangladesh, the treadle pump is a low-cost manually operated water-lifting device. The pump effectively irrigates landholdings of one hectare or less and is thus ideally suited to small and marginal farmers. It is easy to install, requires little maintenance, and has a minimal operating cost. In principle, the treadle pump is similar to the hand pump. However, a hand pump consists of a single barrel or cylinder and water is pumped up with one's hands, whereas the treadle pump has two cylinders and requires foot operation for lifting water (hence called a treadle or pedal pump). One person – a man, a woman, or even a child – can operate the pump by manipulating his/her body weight on two foot pedals or treadles and by holding a bamboo or wooden frame for support, thereby lowering fatigue levels.

The treadle pump is extremely environment-friendly: it requires no fossil fuel for operation and hence there is no pollution; it is extremely energy efficient – it does not require electricity and uses body weight effectively to lift water; and, as the water discharge from a treadle pump (4500–6000 litres per hour, depending on the model) is optimally less than that from a diesel or electric pump, it reduces groundwater depletion. In addition, the pump is designed such that the intensity of water flow does not damage crops.

Affordable micro irrigation technologies

In comparison to conventional flood irrigation, micro irrigation reduces water consumption by at least 50%, reduces both labour requirements and soil erosion, and, above all, increases crop productivity. Despite these advantages, only a small percentage of marginal farmers own these systems. The primary reason for this is that the micro irrigation systems being manufactured are expensive, complicated to operate and maintain, and not designed to fit small plots. In response to these constraints, the IDE has developed AMIT. These are more suited for small farmers because

- the technology is available in convenient packages (in the form of kits) for farmers to install and maintain; besides, farmers have the option to begin with one unit and expand it later at their convenience

- these kits are easily assembled by local farmer groups with some training and back-up

The AMIT kits that are currently being promoted are briefly described here (however, efforts are on to constantly upgrade these kits to cater to the changing requirements of marginal farmers and also to address the irrigation needs of landless farmers).

- The bucket kit is suitable for kitchen gardens for women and landless farmers (ideal for cultivating 20 square metres of cultivable land).
- The drum kit is most useful for kitchen gardens and small commercial vegetable gardens such as tomato, chilli, and okra (ideal for irrigating 140 square metres of cultivable land). Typically, a drum kit can irrigate 520 vegetables with just one 200-litre drum of water filled twice a day.
- The micro sprinkler kit promoted by the IDE is applicable to small farmers living in the hills and in the plains: in the hills the kit is suitable for farmers residing near a gravity-fed stream with a 20-m natural head; in the plains the kit is appropriate for farmers with access to domestic tap water who intend to raise a nursery or grow a mixed vegetable garden.
- The overhead sprinkler kit is highly suitable for close-spaced main field crops such as wheat, green gram, and soybean. It can be run on a 0.5-hp domestic pump; hence, it can also run on a single-phase electric line.

IDE India's treadle pump programme

The IDE India began its treadle pump programme in Orissa in 1991 and soon extended it to other states in the eastern zone where conditions were ideal for the pump. In these areas, the water table is low, landholdings are small, and there is abundant labour for manual irrigation. Today, the IDE is promoting a pump known as the KB pump (brand logo) in West Bengal, Orissa, Bihar, Uttar Pradesh, and select states of the North-East. The product price range (cost to the farmer), depending on regional variation, is between Rs 400 and Rs 1000 ($9–$20), making it one of the cheapest irrigation devices available in India.

Through promotion by the IDE India, the pump went through a series of modifications to become more effective and user-friendly.

The Indian KB pumps are more powerful versions adapted to suit Indian conditions and the needs of Indian farmers. There are four models of the pump in keeping with the distinct soil, water, and income conditions in the different regions of operation. This had a positive impact on market development (in size and geographical spread) as the pumps have different features and prices and farmers can choose according to their requirements and budget. The four pumps are the 3.5″ (barrel diameter) metal pump with bamboo pedals, the 3.5″ metal pump with metal pedals, the 5″ metal pump with metal pedals, and the 5″ concrete pump (PVC barrels) with wooden pedals (for saline areas).

Quality assurance

For the IDE, the quality of a product has always been a major concern as this is a critical and basic factor determining brand equity and customer preference of a product.

In the case of the KB pumps, quality control becomes even more critical as poor quality may cause farmers to reject the product and the new technology as they cannot differentiate between quality problems associated with the product and the technology itself. The KB brand is positioned as a high quality brand, and to maintain this, the following steps have been implemented

- Good CAD (computer aided design) engineering drawings of tools and products with complete specification and tolerances have been generated.
- Controlled copies of these drawings have been issued to QAMs (quality assurance managers) and approved manufacturers.

KB Pumps and their parts are inspected at different stages.

1. *Raw material inspection* The raw material is inspected by the QAM at the manufacturer's end to check the quality of the material.
2. *In-process inspection* During the second stage of inspection, a random sample-based inspection of the components and sub-assemblies is carried out.
3. *Final inspection* Every pump is inspected by the QAM before dispatch. Once the pump is cleared for quality, the QAM issues a clearance certificate and an aluminium punch plate is riveted on the right side of the pump. The punch plate coding helps in tracing the origin of the pump.
4. *Field inspection* The IDE staff conduct a random inspection of pumps that have been grounded. At the distributor/dealer end,

random inspection is carried out to ensure that good quality pumps reach the farmers. Apart from the market feedback from field staff, the QAM visits the field once a month.

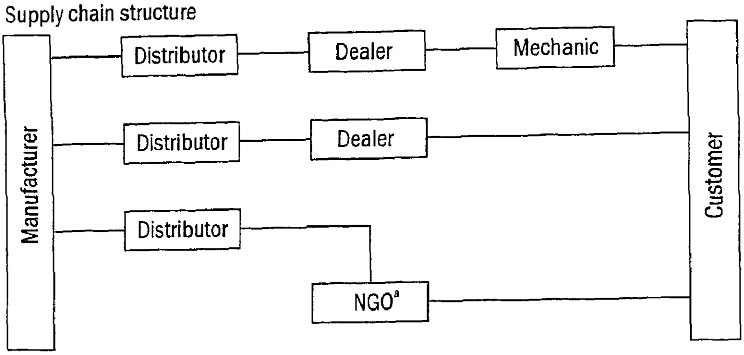
Each KB pump is warranted for a period of 12 months from the date of sale or 18 months from the date of manufacture, whichever falls earlier. A standby pump is installed whenever repair or replacement of the pump is required. Thus, the farmer's work is not affected. The performance of the manufacturers is rated on the basis of different inspection reports/data and field visits. These data provide information about the monthly quality status of the manufacturer, training needs, and scope for higher production levels. To maintain consistency and improve the quality of critical parts, the IDE has centralized the production of the bucket washer, valve, and lock pin. As pump manufacturers were facing recurrent quality problems for these parts, they are now required to procure them from approved suppliers only.

The supply chain

The basis of the IDE's intervention with the treadle pump was that farmers should be able to purchase this technology and benefit from it. A strong and responsive supply chain is critical for the success of any marketing operation. Therefore, a strong supply chain has been the IDE's major concern.

The process of establishing the channel to reach farmers has been carefully worked out. First, the IDE identifies potential and quality manufacturers and motivates them to fabricate treadle pumps on a regular basis (product design and quality assurance are provided by the IDE). Second, the IDE works with these manufacturers to establish a network of distributors and dealers who deal primarily in agricultural and/or hardware items, seeds, fertilizers, and insecticides. Third, the IDE encourages and trains village-level *mistries* to properly install and repair the IDE's products, thereby ensuring after-sales service. Today, the IDE India is working in partnership with 17 manufacturers, 90 distributors, 1040 dealers, and 1345 self-employed mechanics. Over 100 NGOs are part of the dealership network. Till date, more than 15 000 treadle pumps have been grounded in India.

For the IDE, the treadle pump supply chain is a key external resource and an equal partner, built up over the years and not easily changed. It ranks in importance with key internal resources such as field sales personnel and facilities and represents significant



[a] non-governmental organization

Figure 1 Current supply chain structure

corporate commitment to a large number of independent organizations and to customer service. It also represents a commitment to a set of policies and practices that foster long-term relationships. The current supply chain is given in Figure 1.

To make the supply chain effective, the IDE has a stringent selection process for the supply chain members. All roles have been well thought out and strengths and weaknesses well analysed to make this the best possible option for treadle pump dissemination. The same level of detail will be required to establish a supply chain for any other renewable energy technology product.

The IDE's criteria for selecting a manufacturer are as follows

- *Existing products* Manufacturer's production level and capacity of existing products are deciding factors.
- *Financial strength* Manufacturers with financial strength are preferred, especially for metal treadle pump.
- *Manpower* The manufacturer must have the required strength of qualified and experienced staff to make pumps as per specification.
- *Infrastructure* The existing plant, machinery, and scope of expansion are further criteria for selecting the manufacturer.
- *Quality* Quality assurance mechanism, availability of instruments, and gauges is also considered during selection.
- *Distribution chain* A good distributor/dealer/after-sales service network is also desirable.

The criteria for selecting a distributor are as follows.

- Identifying parties dealing in hardware items or in fertilizers and seeds

- Geographical/market requirements (spatial convenience of dealers)
- Capacity to provide credit facilities to dealers
- Market credibility
- Financial capabilities
- A good reputation in the market (this can be ascertained by talking to dealers)
- A well-established delivery system through own or hired transport
- Exposure to the target market (preferably hardware, fertilizers, and seeds)
- Possessing a good dealer network.

The criteria for selecting dealers are as follows.

- Shops dealing in hardware items (the advantage being that they also deal in boring pipes, and thus spare parts required for pump installation would be easily available) or fertilizer/seeds
- Located near an important *haat* (weekly village market) in the IDE's area of operation
- A boring *mistri*, a treadle pump *mistri* and/or self-employed mechanics attached to shops of dealers
- Potential areas / spatial convenience of the target customers / geographical locations in the context of the overall marketing strategy
- Successful track record
- Willingness to spend time to promote the treadle pump
- Willingness to extend credit to customers.

Initially, dealers look to the IDE for promotional and field support for generating business. To increase their capacity to operate independently, the IDE encourages dealers to participate in promotional activities along with the IDE.

Non-governmental organizations also constitute an important link in the IDE's partnership. Since the IDE's inception, NGOs have evinced a strong interest in disseminating the IDE's products to small and marginal farmers. NGOs provide an excellent network for sales, distribution, awareness generation, credit provision through self-help groups, product installation, and after-sales service.

The NGOs that are selected must

- be involved in integrated rural development programmes and projects such as horticulture, agriculture, irrigation, and environment development

- have a good rapport with the people in the work area
- have some funds as revolving funds for KB pump promotion
- have faith in the KB pump and should consider it as an important tool to help marginalized farmers
- be willing to support promotion of KB pumps
- be located in an area where the treadle pump is technically feasible.

Mistries are generally attached to dealers in the market. The IDE organizes training sessions for interested *mistries.* Post-training, the IDE's marketing assistants accompany them for at least the first three installations to assess their work and also to evaluate the impact of the training provided. *Mistries* are the final link in the chain to the farmer – customers, and their technical suggestions are regarded highly in their area of operation. The IDE-trained *mistries* are responsible for correctly installing the KB pumps in the farmers' fields, for after-sales service, and promotion. It has been seen that all efforts are in vain if KB pumps are not correctly installed due to non-cooperation of the *mistries*.

Promotion

The key to the IDE India's success in treadle pump dissemination is its effective promotion in rural areas, using innovative methods of rural marketing. These promotional activities are highly interactive, aimed at creating maximum awareness of the KB brand and, thereby, generating high sales. Promotion forms the backbone of all the IDE's direct field activities, and all promotional activities are executed through the IDE's field staff, dealers and independent *mistries* for creating awareness and generating sales of KB products.

During promotional activities, efforts are made to simultaneously achieve both product promotion and brand promotion. The former highlights the advantages and features of the pump, that is, water independence, low cost, portability, and no cost of operation, whereas the latter promotes the KB brand as a quality product backed by a reliable and trained after-sales service network.

Branding was found to have the following advantages: high recall value, uniformity in all product promotion, and hence a strong brand association, a symbol of quality and reliability, assisting in leveraging brand equity.

Some of the dynamic promotion tools used by the IDE are as follows.

- *Haat demonstrations* *Haats* are weekly village markets. In the IDE's experience, it is an ideal location to introduce, demonstrate, promote, and create a demand for new technologies or products. Usually, a team comprising a marketing assistant/*mistri* and/or a dealer representative demonstrate the working of the treadle pump at these markets. Banners with the nearest dealers' names are displayed prominently, and audio cassettes with songs and jingles are used to attract crowds.
- *Melas* A *mela* is an important social event that caters to a very large audience. It is an excellent and low-cost platform for introducing new product concepts and for creating mass awareness about products. For the IDE's purpose, commercial *melas* are the most suitable as people come with the specific objective of buying. Hence, setting up sales outlets and having the dealers share the cost is a very effective way of using this platform.
- *Short campaigns* The objective of short campaigns is to create interest and awareness among traders and farmers. These campaigns are best arranged just before the onset of the peak season or when commencing operations in new areas. Short campaigns involve live demonstrations by using video and/or audio systems in vehicles such as tempos and jeeps at *haats*, the market place, or important locations in the village.
- *Farmers' meetings* Farmers' meetings are a major promotional tool for discussing better cropping practices, providing agronomic inputs, and explaining the IDE product benefits. These meetings with a group of 15–20 farmers usually last for 45–60 minutes. Live demonstrations are important in establishing the credibility of KB products and are arranged by the IDE field staff in the initial meetings. The field staff tries to clear doubts raised by the farmers and collect feedback from those who have been using the pump regularly. Opinion leaders and persuasive people are also targeted during these meetings. During follow-up visits, meetings are arranged at a pump site in a satisfied farmer's field. The satisfied farmer helps to reinforce the various benefits of the pump and, thereby, acts as a spokesperson for the IDE product.
- *Demonstration plots* The main objective of demonstration plots is to create awareness of, and interest in, the treadle pump by showing the pump in operation along with the different crops that can be grown with the help of this technology.
- *Video van show* One of the most innovative promotional tools used by the IDE is the video van that enables it to reach out to a

> fairly large audience at a time. A movie revolving around the KB pump and an advertisement are screened. The shows are usually conducted in the evenings at a prominent place in the village, with field staff of that area and the dealer and distributor present to respond to farmers' queries and concerns about pump availability and purchase.

The *Graphics Standard Manual* has been developed for standardizing static promotional materials across regions. The IDE has pursued an innovative and creative promotional campaign, which has generated tremendous awareness about the KB treadle pump in the targeted areas.

After-sales service

For a performance-oriented product like the treadle pump, a strong after-sales network is essential for continued satisfactory service. After-sales is important to the KB pump market because good after-sales service will build satisfied customers who in turn will create multiple demand for KB pumps. Generally, pumps are sold by KB dealers and installed by the dealers' *mistries*. Therefore, the dealer is responsible for repair/replacement under warranty. In instances where the installation has been done by an open-market *mistri*, the warranty on the pump will continue, but the responsibility for rectifying any installation defects will rest with the local *mistri*. To ensure this, incentive through cash or kind may be necessary in the initial stage. From the IDE's point of view, the concerned marketing assistant / master *mistri* is responsible for ensuring that the pumps are in good working condition.

In terms of after-sales services, the IDE is engaged in

- establishing a good *mistri* network and providing training on proper installation and maintenance
- providing training to farmers on minor repairs and maintenance
- ensuring that pumps are in a good working condition
- ensuring a consistent availability of spares at dealer points so that complaints can be attended to promptly
- providing quality assurance through the warranty card and installation manual.

Training

Training to augment efficiency and ensure efficient after-sales service has been an integral part of the IDE's core marketing strategy.

It forms a vital component of marketing operations at large, with the following broadly delineated objectives:

- to ensure uniform and quality production of the IDE's KB pumps
- to foster efficient marketing and after-sales service of the pumps by the IDE staff
- to build the capacity of NGOs so that they can market their own products and KB pumps with an ultimate view to reducing dependence on the IDE for promotional activities.

To realize these objectives, training and orientation is imparted to

- the IDE's staff consisting of regional marketing managers, district marketing managers, and marketing assistants
- KB partners comprising manufacturers, dealers / distributors, *mistries*, village agricultural workers, NGOs, and the farmer who is the ultimate user.

The IDE focuses on imparting training to partners at the grassroots level, that is, the *mistries* and the village agricultural workers in Orissa. The latter are considered at par with the *mistries* as they are responsible for the correct installation of KB pumps. These training programmes are conducted primarily by the marketing assistants and are executed in a very informal setting, mostly in villages. The focus is on introducing the IDE and the treadle pump and on explaining the business benefits associated with, and the procedures involved in, pump installation and maintenance. Such training intervention has also been targeted at village-based women's groups. Women also receive training in agronomy as part of the IDE's integrated development programme.

Training programmes for NGOs are meant to orient them and to empower them into becoming a true extension of the IDE in promoting and selling KB pumps. These training sessions focus on the IDE as a social marketing organization, as well as on marketing principles in general, accounting, management information system and the like.

To nurture and consolidate the supply chain partners and to keep them motivated, the IDE organizes regular meetings. This strategy has ensured a forum to raise and resolve critical issues. The IDE conducts an annual manufacturers' meet, which is both a public relation gesture and a training forum. Dealer meets are organized once in every season by each field office, and the focus is on improving links with the distributor and on margins, incentives, and future marketing strategies. The users' training programme is an informal programme imparted to farmers by the *mistries* or marketing assistants during or after pump installation. The basics of maintenance and repairs are explained to the farmers at their sites.

Training activities are undertaken by the regional office staff, the IDE's mobile training teams and NGOs. The mobile training teams comprise one marketing assistant, an agronomist, and/or a *mistri.* Training aids such as flip charts and handbooks have been developed to enable regional staff to conduct effective and consistent training programmes. The IDE's *Marketing Handbook* is an extremely useful resource tool for the field staff. It is produced in regional languages, wherever necessary, to overcome communication language barriers.

Agronomy

Agronomy constitutes an important component of the IDE's marketing strategy and is an effective tool not only for after-sales services but also for attracting new customers. The IDE's agronomic inputs include providing assistance to farmers regarding selection of seeds, judicious use of pesticides and fertilizers, advice on better cropping practices, etc. The IDE's field staff is technically trained to offer such advice. The IDE also enters into partnerships with reputed agro-companies to procure good quality seeds and fertilizers for use in its demonstration plots.

Management information system

The IDE has developed a comprehensive MIS package to track pump-and sales-related data at the field level. Such data enable an understanding of market reactions and dynamics and, therefore, help in taking policy decisions, especially on operational strategies.

Current status of IDE India programmes

The IDE India's treadle pump programme is entering a crucial phase in which sustainability of the supply chain is to be established over the next few years. This process will ensure that treadle pumps will continue to be manufactured, distributed, and purchased by different members of the chain without the involvement of the IDE.

The AMIT programme is poised for growth now that the initial field-testing and test-marketing stages have been completed. The systems have been rigorously tested with sericulture farmers, watershed projects, cotton farmers, vegetable growers, small farmers, landless women, and self-help groups in selected areas of Rajasthan, Maharashtra, Himachal Pradesh, Gujarat, Madhya Pradesh, and Karnataka.

Rural marketing of renewable energy technologies

For most renewable energy technologies in India, the transition from laboratory to market shelves to customers' hands has been difficult and not to the expected or desired degree. Although extensive R&D has taken place in the technologies themselves, little success has been achieved in commercializing these and in making them available on a large scale.

The whole concept of renewable energy technologies may be unclear to rural people; marketing is thus difficult, as the concept has to be sold along with the product. The toughest marketing challenge is to introduce a new concept and a new product in a new market through a new channel. The IDE has successfully done this with irrigation technology and is now looking to renewable energy technologies as the new challenge. In 1999, the IDE test marketed a solar lantern in eastern India in a pilot project supported by Winrock International.

The IDE's experience thus far has been that a market for specific renewable energy products is better than a general market for renewable energy products. For example, the market for solar-powered lanterns may be very different from the market for a solar drier or a water mill turbine. In other words, the market is based on the product, as valued by the customer; it is not based on the energy source.

One of the most crucial aspects of marketing renewable energy technologies in rural areas is the presence of a supply channel suited to the particular product. One may have to create a totally new channel or modify an existing channel.

In marketing a new technology/product, the product needs to be introduced properly. For a successful product launch, it is very important to consider the following

- The product launched should be of an exceptional quality since first impressions are vital to the acceptability of the new technology. Poor rural buyers are generally risk-averse and do not have the economic means to experiment with technologies. If product performance is unsatisfactory, farmers will reject the technology.
- The product must fit the market niche as determined by geographical and cultural factors as also the price of the product/

technology. The focus should not be on the technology itself but on whether the technology/product is attuned to the needs of farmers and their budget.

- There has to be a well-thought-out investment and marketing plan for the product. The most brilliant product often fails in the absence of proper planning.
- Heavy investment is essential in the initial promotion phase since the concept of renewable energy has to be sold to farmers who may be totally unaware of it. Once the concept is established, the promotion costs per product will fall.
- The timing and location of the launch is critical to ensure success.

Successful mass marketing requires modifying technology to meet customer expectations in terms of cost and performance, backed by suitable distribution and promotion strategies. To successfully market renewable energy technologies, one has to know the product, the competition, the customer, and one's own strengths and weaknesses in terms of ability to promote the technology. If the product is not suited to the customer or the competition is stronger, all efforts to market the technology will be wasted. Each technology needs to be viewed from the following perspectives: product, price, promotion, and place.

Conclusions

Clearly, rural marketing in India is a challenge.

- Traditionally, farmers are conservative, slow to accept new ideas and products.
- Usually, the markets are inaccessible, badly connected and have poor infrastructural facilities.
- It is crucial to establish credibility for any marketing effort to be successful in rural areas.
- Farmers are risk-averse and need to have the technology proven to them before they spend money purchasing the product.
- For selling products valued at a few thousand rupees, it is necessary to identify or create a reliable system for extending credit.

With its expertise in rural marketing of appropriate technology, the IDE can play a pivotal role in establishing sustainable, custom-designed rural marketing strategies for renewable energy technologies.

Development of products and rural market for biogas

Joe Madiath

Gram Vikas is a non-partisan, secular, voluntary organization working in South and South-West Orissa. The mission of Gram Vikas is to promote a sustainable process towards a dignified quality of life for conscientious rural communities characterized by

- opportunity for secure livelihoods
- ecologically sound upgradation of natural resource base
- access to basic education and primary health care
- access to safe drinking water and hygienic living conditions, and
- enhanced self-reliance and self-esteem.

Gram Vikas was founded by a group of student volunteers from the Young Students' Movement for Development, Chennai. Gram Vikas directly reaches out to nearly 25 000 households in 450 villages in 12 districts of Orissa. The two main programmes of Gram Vikas are the Integrated Tribal Development Programme and the RHEP (Rural Health and Environment Programme). The sectoral thrust areas of both programmes, which work towards a holistic development of villages and rural communities, are education, health care systems, infrastructure, energy, sustainable livelihoods, and, most importantly, people's self-governance.

Renewable technologies

Gram Vikas' association with renewable energy began in 1977, with the construction of a biogas plant of 8-cubic-metre capacity for the organization's farm campus. This was utilized for cooking and lighting purposes as the area was unelectrified till 1982. This was followed by a 15-cubic-metre Janata model biogas plant, which too was sited at Gram Vikas headquarters.

In the initial years in Kerandimal, it was noticed that the forests were receding by about half a kilometre every year. Logging was rampant, with contractors working in collusion with the forest

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Gram Vikas, Post Mohuda, Via Berhampur, Ganjam, Orissa – 760 002, India

department, selling valuable timber at throwaway prices. The villagers used to fell trees to meet their fuel needs and often worked for contractors for a small remuneration. Indiscriminate felling, i.e. without distinguishing mature and tender trees, caused greater damage. Deforestation was a major problem not only in Kerandimal but also in the rest of Orissa.

The sizeable cattle population of Orissa, plus our hands-on experience in operating biogas plants, made us consider biogas as a viable alternative. To meet the fuel needs and to reduce deforestation, Gram Vikas decided to propagate biogas. In 1981, the first community biogas plant was installed in a small inaccessible village called Toda, located on a hilltop in Kerandimal, to illuminate the village. Soon, community plants in nine other hamlets were set up.

Around the same time, the agriculture ministry expressed its interest in spreading the technology. The Janata model, based on the Chinese technology of a fixed dome, was in vogue and we adopted the same. When the NPBD (National Project for Biogas Development) was nationally initiated, we were drawn into the vortex of the programme, by virtue of being one of the few organizations with a proven experience in biogas. Gram Vikas first collaborated with the agriculture department and subsequently with the nodal agency, which was set up exclusively for the propagation of renewable energy in Orissa.

Need to expand

The perception among bureaucrats, multilaterals, bilaterals, and the public was that non-governmental organizations were unable to undertake large-scale and technology-based interventions, and that efforts would, at best, be configured to localized demonstrations, never extending to a mass dissemination of technologies in a sustainable cost-effective manner. Armed with the benefit of some initial experience, Gram Vikas decided to take up the challenge and operate at the state level. Gram Vikas started working simultaneously in most districts of Orissa, since the need for alternative fuel was universal.

Implementation process

The initial efforts were in demystification of the technology involved in the installation of biogas plants. The intention was to first stabilize the models, and then train 'barefoot engineers' to spread the technology. These persons would have the necessary technical and managerial skills to effectively undertake and supervise the construction of biogas plants. This was no mean task as the construction of biogas plants requires a high level of skill. The plant has to be totally gas-tight, not even allowing methane, the smallest molecule of gas, to pass through.

By that time, Gram Vikas had designed and perfected the Deenabandhu model of biogas plant. Further, the 2-, 3-, 4-, and 6-cubic-metre capacity plants were standardized and a massive training programme was started for masons and supervisors. The masons were responsible for the construction while the supervisors were in charge of plant installation, overall supervision, and regular maintenance of biogas plants. The supervisors were also responsible for motivating farmers, arranging loans, helping in acquiring subsidies, etc. but never actually handled cash. They accompanied villagers to the banks and government offices and helped them in filling up the necessary forms. In the process, the farmers internalized a sense of complete ownership over the plants.

For purposes of regular maintenance, the supervisors periodically visited every household that had installed a biogas plant and maintained meticulous records on various problems, complaints, etc. The users were also given postcards with a maintenance request printed on them, which could be mailed whenever required.

Scaling up

The programme was intensified in 1984. For the first 2–3 years, intensive campaigns were undertaken by Gram Vikas staff to motivate rural communities to take up the construction of biogas plants. After the initial successful demonstrations in each area, there was a definite shift from the 'push' factor to a 'demand pull'.

Between 1984 and 1994, Gram Vikas installed 54 047 plants in over 6000 villages spread over 13 (undivided) districts of Orissa, including the tribal dominated districts such as Ganjam, Koraput, Sundargarh, Sambalpur, and Mayurbhanj. These plants accounted for about 80% of the existing biogas plants in Orissa and about 4% of the plants in India. Significantly, the Orissa government received awards for three consecutive years for the promotion of biogas technology and for the highest number of working plants.

At the peak of the programme, around 1992/93, 7000–10 000 plants were set up each year. Discussions focused on diversifying the base of the programme to adopt a more integrated approach towards rural development. The RHEP was born out of the experiences of working closely with rural communities in the biogas programme. The RHEP focuses on developing protected piped water supply and sanitation systems, health care, education, community and individual livelihood activities, biogas and composting in entire villages.

Under the RHEP, every family in the village is involved and the initiation of the programme is subject to the generation of a corpus fund by the village, to which every household contributes Rs 1000 on an average. The RHEP is a time-bound programme spanning three years. The norms for the implementation are listed out and a formal agreement is signed by the village executive committee and Gram Vikas, prior to programme initiation in the village.

Spinning off

Gram Vikas initiated the spinning-off process of the biogas programme in 1994 with the expectation that the supervisors and trained masons would become independent turnkey operators and entrepreneurs with little difficulty. They would facilitate interested farmers in accessing loans and subsidies for constructing plants, provide the necessary technical support, and work as independent turnkey operators. The large pool of skilled and experienced personnel would work independently or with other local voluntary organizations to promote biogas all over the state. The supervisors and masons were encouraged to take up entrepreneurship either individually or in small groups or in association with other local bodies. Gram Vikas would continue to provide technical support and the necessary credibility to establish their enterprise. Further, they were offered the option of returning to Gram Vikas if they failed in their effort. After two years, only 6 of the 500 supervisors returned.

In 1997, Gram Vikas conducted a survey of the biogas plants constructed and found that 82% was still in operation.

Mechanism for development and implementation

It would be worthwhile to examine the mechanisms used by Gram Vikas to develop and implement biogas plants. Prior to Gram Vikas' efforts in the field, the KVIC (Khadi and Village Industries Commission) had established a proven model, with advantages like gas tightness and easy installation. However, it had the following demerits.

- The gas holder had to be fabricated
- The fabrication of the gas holder required the availability of mild steel, electricity, and a highly-trained technician (welder).

- The gas holder could not be transported to remote villages, as they could be accessed only by footpaths winding up steep hills.
- The gas holders tended to rust within a few years and spring leaks, which could not be plugged or repaired in these remote villages.

As Gram Vikas was working mostly in non-electrified villages without connecting roads, the search began for a model of biogas plant that could be manufactured in the village itself by a well-trained villager-turned-mason. The search seemed to conclude with the development of the Janata model biogas plant, which could be constructed in any village by a well-trained mason. The problem of costs surfaced due to the high consumption of cement. Although this model was cheaper than the KVIC one, an even more inexpensive model was needed since the clients were mostly small and marginal farmers and tribals. Gram Vikas began systematic experimentation together with research organizations within the country and outside and ultimately developed the Deenabandhu model biogas plant. This was substantially cheaper than the other models, and trained masons could construct these plants in the villages themselves. Gram Vikas was certain that the Deenabandhu model could be marketed to rural and even tribal Orissa. Today, this model is the most popular one in India.

Training programmes were conducted in villages where the biogas programme was being implemented. The unskilled village youth were the primary targets since veteran masons experienced a few difficulties in adopting the new method. The construction of biogas plants requires an adaptation of conventional masonry skills, concrete mixes, brick-laying, plastering and compaction methods, meticulous curing, etc.

Fresh trainees were often more receptive, and, thus, Gram Vikas transformed over 5000 unskilled labourers into skilled masons during the 10 years of the programme. Today, all these persons have gainful employment and secure livelihoods.

At least one well-trained supervisor (the 'barefoot engineer') was positioned in each of the blocks that Gram Vikas worked. An adequate number of masons were trained in the construction of biogas plants. Another cadre of unskilled labourers was also trained in plumbing so as to lay the pipelines from the biogas plants to the households.

Once the product – Deenabandhu biogas plant – and the machinery for implementation – the barefoot engineers, the trained masons and plumbers – were all in place, Gram Vikas focused on marketing the product. The supervisors initially targeted big farmers or farmers who had a lot of cattle. There were very few takers in the beginning as farmers did not want to take chances with a technology that produced cooking gas without the use of machines. To overcome this problem, Gram Vikas assured a full refund in the event of a plant failure during the first two years.

It would seem contradictory that an organization purporting to work for the weaker sections of society was, in fact, working with affluent farmers. There was a justification for this. More than 80% of the fuelwood available in a village was usually cornered by less than 10% of the population. Hence, approximately 90% of the population had access to less than 20% of the available fuelwood. This, in turn, made them dependent on leftover agricultural waste and animal dung to meet their fuel requirements, or they had to travel long distances for fuelwood.

Once the cooking fuel needs of big farmers were met through biogas, at least 80% of the fuelwood was available to 80% of the population. This was a direct benefit to the target section. The next group to be targeted were the small, marginal, or landless farmers with sufficient cattle to supply the feed material for the functioning of a biogas plant. However, these farmers had by now come to believe that only the rich big farmers could afford/operate biogas plants, a belief encouraged by these farmers. Again, Gram Vikas provided assurances of a full refund in the event of plant failure.

It took over five years to implement fully the biogas programme —the 'demand pull' took effect only after the resounding success of the initial plants after the people had experienced the benefits of biogas and were comfortable with the technology. Therefore, while quantity did matter, quality was of supreme importance as even one failed plant had greater negative impact than a hundred successful plants.

Gram Vikas considers the spinning-off of the biogas programme – where biogas employees undertook independently the construction of biogas plants – as the culmination of the marketing of biogas in Orissa by Gram Vikas.

Developing rural entrepreneurship to promote photovoltaic systems

Harish Hande

Introduction

Renewable technology, especially photovoltaic systems, is considered to be expensive and not affordable for the poor, though user value of this technology outweighs the disadvantage of its high cost. However, to get the rural population to understand and accept this technology, there is need to have private entrepreneurs who will explain its functions and advantages in the local language. Apart from different financial mechanisms to buy the systems, a lot of support in terms of training, working capital, etc. is required for the entrepreneur.

Local entrepreneurs

Entrepreneurs have to know the technical details of the technology and should be innovative in their approach. They have to go to the customer and explain the benefits of using photovoltaic systems in a language which the customer understands. Further, as these systems have a loan component, entrepreneurs should be able to handle financial transactions. The entrepreneur and the technician need to build a good rapport with the customer because not only are they installing a particular system but also promoting it to many other people who will come to look at the same. The point is to keep the customer happy and this is achieved through marketing. For renewable systems like photovoltaics where technology is being promoted, separate marketing and technical teams or departments would not help; as the technicians are directly and continuously interacting with the users, they are the best people for marketing.

To promote this technology, we need to develop entrepreneurs who are capable of handling supplies and marketing.

Selco Solar Light Pvt. Ltd, #229, 15th Main 24th Cross, Banashankari II Stage, Bangalore – 560 070, India

The technology cannot be promoted successfully without this vital link of capable entrepreneurs. To develop effective rural entrepreneurs, the important factors which need attention are

- training
- financing
  - working capital for the entrepreneur
  - innovative schemes for system financing.

Enormous patience is required to promote this technology because the learning curve is very steep. The acceptance curve, however, is not as steep. So patience and motivation need to go hand in hand. There are many entrepreneurs who are highly motivated but do not get the right break, encouragement, advice, and training. Selco has many entrepreneurs who have been with it for the last 10 to 12 years. This is a result of constant follow-up, advice, and information on changing technology and finance mechanisms, all of which can help entrepreneurs implement this in their own areas.

Training

Entrepreneurs in rural areas are intelligent, and contrary to general belief, can assess the product and its market. But they need basic technical details of the technology, its specifications, and proper installation of the system. Entrepreneurs need training in handling the financial aspect and understanding the financing network in rural areas so as to enable them to offer financial packages to the users.

Further, this training needs to be given through a simple, easy to understand training programme to rural entrepreneurs and should be conducted in rural areas where the technology is actually being promoted.

As entrepreneurs are offering a technology that is considered 'expensive', they should be able to explain and present in great detail the advantages of the technology.

There is lot of potential in rural areas; therefore suppliers and manufacturers of photovoltaic systems should come forward to encourage entrepreneurs in rural areas. This will help create an independent market.

Financing

To succeed in propagating the solar photovoltaic systems, a rural entrepreneur will need.

- working capital
- innovative financing mechanisms for system financing.

Working capital financing in photovoltaics has been completely neglected. The financing institutions in rural areas, like cooperative banks, have doubts about the repaying capacity of an entrepreneur who takes a working capital loan.

As entrepreneurs have to stock five solar photovoltaic systems – equivalent to the salary of four technicians – for a whole year, they need working capital to start their business.

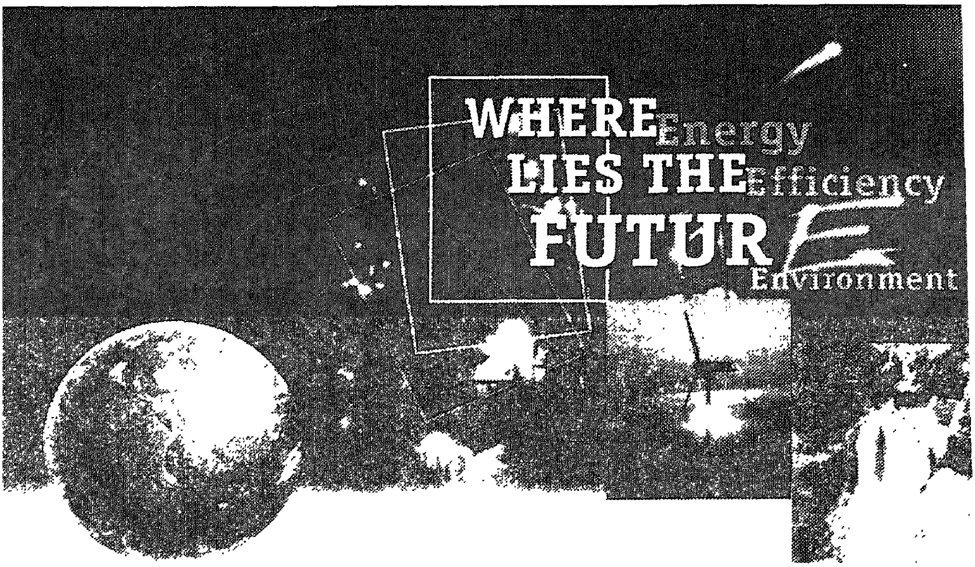
Financing is always at the two ends of the market – the manufacturing/supplying and the end-user – but vital link of the entrepreneur is missing.

A parallel working capital finance also needs to be created for training in rural areas. An opinion regarding the efficacy of rural training centres cannot be based solely on surveys or market research. In fact, there are some good training courses in rural areas. The good ones can be chosen, and specific banks, which are reliable and patient, can finance these, thereby helping to spread this technology in rural areas.

Besides banks, rural cooperative societies can also aid entrepreneur training centres. Once a good and robust working capital chain is created for the entrepreneurs, a sustainable network for financing the end-users will automatically come into force.

System financing is an important factor in the case of solar photovoltaics. Different schemes are available to fulfil this requirement, but all financial policies and mechanisms have an urban bias and are rarely implemented in rural areas. There is a need to bridge this rural–urban gap for which the manufacturer–supplier–entrepreneur linkage could be used very effectively.

Till today, Selco's systems for individual houses has never relied on subsidy. People have bought four light systems at Rs 18 500 or two light systems at Rs 11 500. Clients range from tribals to big planters. None have ever asked for subsidy because of the user-value a solar photovoltaic can add. If the technology is properly marketed there is no need for subsidy. The subsidy, if any, should be used to reduce the interest rate. In this way, the entrepreneur is not dependent on the external factor of subsidy and can deal with customers directly.



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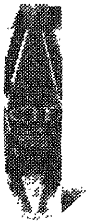

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SDC-TERI experience on product development – case 1: design, development, and field testing of gasifier-based silk reeling oven

Sunil Dhingra and V V N Kishore

Background

TERI (Tata Energy Research Institute) has been actively involved in the development of a biomass gasifier for the silk reeling industry. Though the basic science of gasification is well established, not enough effort has been made on product development in the past. By continuous interaction with users, silk experts, and consultants, TERI has developed a gasifier-based silk reeling oven. The present paper gives an account of the design, development, and testing of the gasifier-based cottage basin system for cocoon cooking in the silk reeling industry in order to achieve higher fuel efficiency and increased productivity. The paper describes in detail the different stages of development, its testing in both in the laboratory and the field, and the economic viability of the system. The paper also describes in detail the cost-benefit analysis of the system.

Introduction

Silk holds a unique place in the textile world and is regarded as the 'Queen of Textiles'. India which is ranked only next to China in silk production is a traditional sericulture country and produced around 14 500 tonnes of natural silk during 1993/94. Silk is generally reeled either in the charka ovens or in the cottage basin ovens. At present, there are about 35 155 charka ovens and 25 937 cottage basin ovens installed in different states. Fuels used are mainly firewood for the cottage basin and locally available loose biomass (such as groundnut shell, tamarind husk, rice husk, and coffee beans) for the charka units. It is estimated that about 105 000 tonnes of loose biomass and 120 000 tonnes of fuelwood are consumed every year for the production of silk yarn. The profitability of silk reeling is marginal and highly sensitive to fluctuations in cocoon/silk prices, which are beyond the control of the reelers. In addition, the overall productivity of the

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sector is low as no attempts are made at technology upgradation, energy conservation, by-product recovery, etc.

Survey of silk reeling ovens

A survey was conducted on 236 cooking ovens followed by detailed energy and water balance experiments on sample units to establish the energy use pattern. The specific fuel consumption level of about 1.5–2.0 kg-wood/kg-cocoon is obtained in the case of the cottage basin oven and 2.44–3.2 kg-fuel/kg-cocoon in the case of the charka oven. The flue gas losses are higher (32%–37%) in case of the charka oven than for the cotton basin oven (24%–34%). Thus, the overall efficiency of the cottage basin oven is 11.7%–15.3% only. Based on the water balance exercise, it was found out that the useful heat requirement for cooking 1 kg of cocoon, following the current practice, is about 1300 kcal in the case of the charka oven and 875 kcal in the case of the cottage basin oven. The reasons for the higher value of the charka oven can be attributed to the longer period of operation and the larger cooking vessel area. The study also revealed that the majority of the charka units use locally available loose biomass for fuel while the cottage basin ovens consume firewood.

The present ovens have inherent disadvantages like no control on fuel burning, large fluctuation in process parameters like water temperature and level of water in each vessel, and frequent manual interference. Therefore, the present system offers a large scope for efficiency and design improvement. Seasonal variation in the type of fuels used in the charka oven makes it difficult to develop a common design since burning characteristics change drastically for each fuel type. However, as the cottage basin oven consumes a lot of fuel, an alternative for wood logs can go a long way in alleviating the deforestation problem. Also, as the cottage basin reelers have comparatively good financial stability when compared to charka reelers, they can go for retrofitting or even adopt newer designs of the stove if they are economically attractive interventions. Retrofitting of ovens by way of controlled burning rate, maximum flue gas heat recovery, and reducing other losses can result in marginal energy saving (about 25%) and, therefore, are less likely to attract reelers. Hence, there is a need to develop an alternative design suitable for meeting the energy demands of the silk reeling unit with substantial fuel saving so as to make it an economically viable intervention.

Considering the unavoidable evaporation losses and the necessity to have controlled burning, the gasifier system appears to be a promising option. In the following sections, different stages of the development of a gasifier-based cottage basin oven are described.

Development of various prototypes

Cottage basin silk reeling units are categorized based on the number of reeling and cooking basins. Generally, one cooking basin supplies cocoons to two reeling basins. Based on the representative data of a survey on silk reeling ovens, a six-pan cottage basin oven was selected for gasifier-based prototype development and testing. The development work of the gasifier-based cottage basin system was initiated through series prototype fabrication and their testing.

Conceptual and laboratory prototype

To prove the concept of the possibility of extending gasifier application to cocoon cooking in cottage basin ovens, a prototype was fabricated and tested at TERI's Gual Pahari campus. Figure 1 gives an overall view of the prototype, showing the system layout and its components. The gasifier selected for this application is a downdraft, throatless type and offers advantages such as less tar and particulate matter in raw producer gas, minimized fuel-bridging problem, and use of comparatively larger wood chips compared to the updraft and cross-draft gasifiers. A water seal tank is placed below the gasifier to collect ash and char.

The prototype unit was operated primarily to test the concept of extending gasifier application to cottage basin silk reeling ovens. Trial

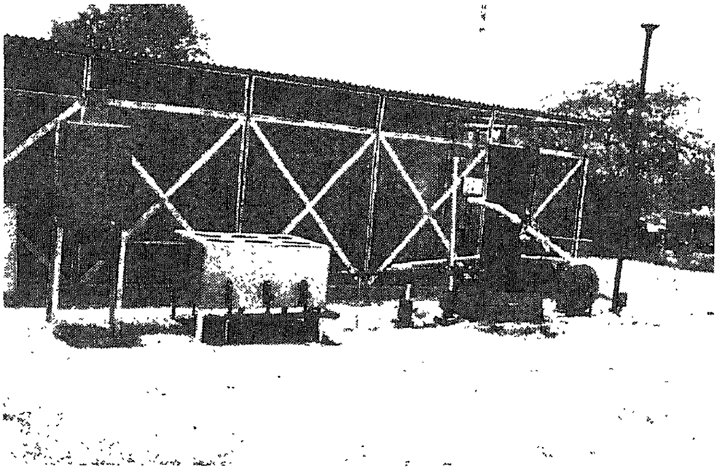

Figure 1 Overall view of the prototype showing system layout

runs on the system proved that the concept improved the efficiency of the cottage basin ovens substantially. During testing, a few operational problems were also identified such as blockage of the pipeline, frequent fuel feeding, and fluctuation in the burner power. This resulted in modifications in the gasifier and other components so as to evolve a laboratory prototype system. These modifications were the introduction of a separate flaring pipe and the introduction of a gas bubbling chamber immediately after the outlet of the gasifier to minimize blockage of the gas pipeline. Laboratory testing of the system was designed to assess maintenance requirements and the reliability of the system for continuous operation on a daily basis.

Field prototype (Hindupur)

After successful completion of long-duration testing of the gasifier-based system at TERI for reliability and maintenance requirements, a field prototype was designed keeping the following points based on experiences with earlier prototypes in mind.

- Sizing of the system for field requirement
- Ease of fabrication and installation of the system in the field
- Possibilities of reducing the system cost
- Possibility of reducing maintenance requirements.

Hindupur region is dominated by charka ovens and there are only a few cottage basin ovens, that too operate on part load. This provided the right opportunity to experiment with a new technology. The Kedar Silk Reeling and Twisting Unit, Hindupur, Andhra Pradesh was selected for field testing.

The first field prototype of the gasifier-based cottage basin system was installed at Hindupur on 9 November 1995 for testing performance under actual field conditions. The concept of utilizing a wood gasifier system for cottage basin silk reeling ovens has been developed and tested successfully both at the laboratory level and under actual field conditions. Therefore, it was decided to further develop the system to suit the field conditions of Ramanagaram, Kanakpura, etc. where the population of cottage basin ovens is too dense to carry out a comparative analysis.

Evolution of industrial prototype (Mark 4)

Till the comparative testing of the gasifier-based silk reeling oven at Ramanagaram, attempts were focused on field testing of the gasifier system in the silk reeling industry. The main objective was to develop a suitable gasifier and sub-system assemblies like the blower, a cooling and cleaning system, an efficient burner, and to reduce the maintenance requirements of the system. However, the cooking oven design, the vessels, and the heat recovery drum remained unchanged because it was felt that too many changes in the first attempt were undesirable. Therefore, in the development of the industrial model, the main attempt was to redesign the oven to

- meet the field process parameters
- increase the overall thermal efficiency
- reduce the masonry construction
- make the whole assembly like a standard factory product
- reduce the maintenance requirements of the system

In the industrial prototype design, all the useful suggestions received from different manufacturers and consultants were also considered. The cooking vessel was constructed as a single water bath with four perforated partitions. The oven structure was changed to metal fabrication work and the gasifier remained more or less the same. The modified water bath was made as a single large vessel with four partitions instead of six individual pans as in the case of the earlier system. This allows the temperature to be maintained uniformly within a narrow band for all the cooking pans. The temperature of the cooking water was recorded during cooking operation in both the conventional and the gasifier system. The data was plotted and is shown in Figures 2a and b.

The temperature of the cooking water is always maintained between 93 °C and 97 °C throughout the cooking whereas in the

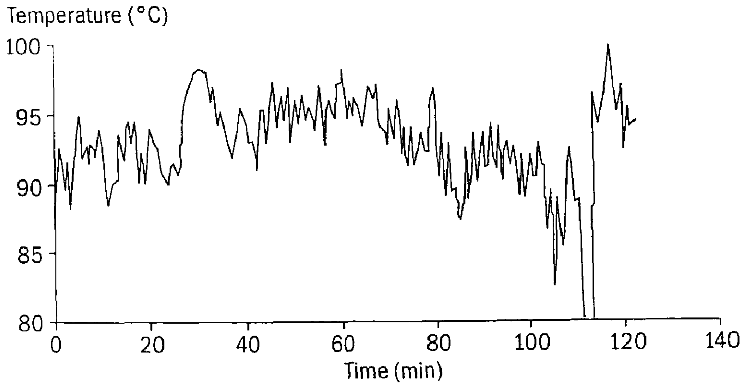

Figure 2a Time, temperature profile during cocoon cooking in conventional oven (25 September 1997)

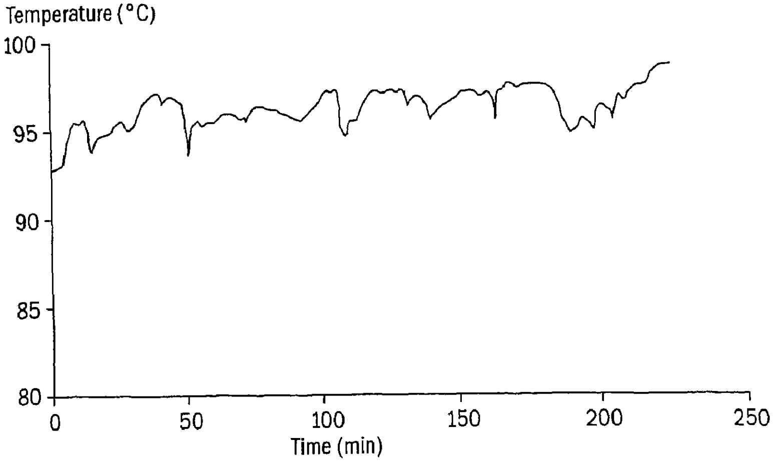

Figure 2b Time, temperature profile during cocoon cooking in Mark 4 gasifier system

conventional oven, the cooking water temperature varies between 80 °C and 98 °C apart from the individual variation of each cooking pot. The uniform temperature band further improved the silk yield and the quality of the yarn as well. Due to higher heat transfer area, better surface insulation and improved burner efficiency compared with earlier models, the energy efficiency of this prototype increased further by 15% and thus more fuel was saved. The photograph of the industrial prototype in actual use is shown in Figure 3.

The different stages of development with the total monetary benefit of the system are shown in Figure 4. It can be seen from

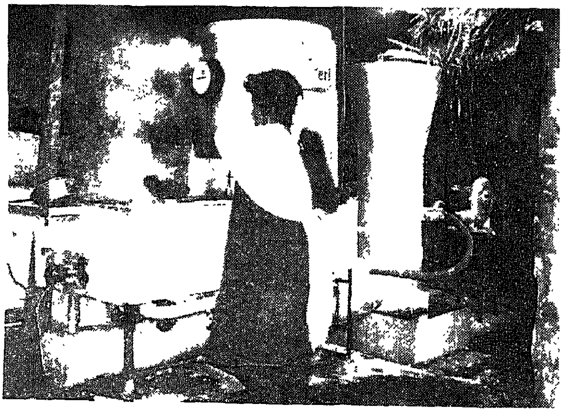

Figure 3 The industrial prototype in actual use

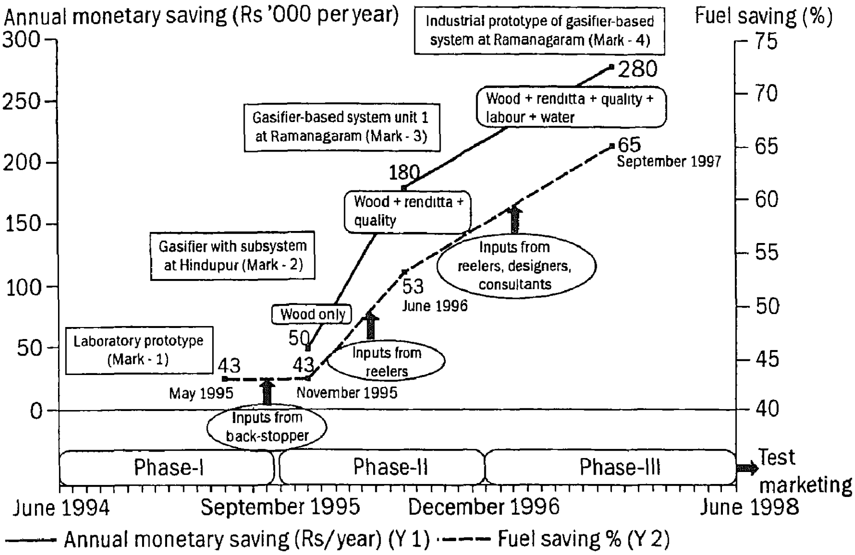

Figure 4 Different stages of development with total monetary benefit

Figure 4 that wood saving increased from 43% to 65% and monetary benefits of the system increased from Rs 43 000 to Rs 280 000 in the change from the laboratory model to the industrial model.

Results of field testing (Ramanagaram)

Comparative performance tests were carried out on the industrial model of the gasifier-based systems at Ramanagarm, Karnataka, on two different sites. For this purpose, a single lot of cocoons was divided into two parts. One was processed in the conventional oven and the other in the gasifier oven. A total of 82 comparative performance tests were carried out on both the systems. The data regarding specific fuel consumption is summarized in Table 1. It can be seen from Table 1 that the specific fuel consumption is reduced from 2.64 kg-fuel/kg-cocoon to 0.98 kg-fuel/kg-cocoon for Unit I and from 2.0 kg-fuel/kg-cocoon to 0.87 kg-fuel/kg-cocoon for Unit II.

Further, the statistical *Z*-test analysis of all the data points (68) is done at 95% and 99% confidence level. The *Z*-test results are given in Table 2. The 59.7% and 59.2% reduction in specific fuel consumption was observed at 95% and 99% confidence levels respectively, indicating substantial fuelwood savings.

The data related to silk yield production is summarized in Table 3. It can be seen from Table 3 that extra silk yields of 4.22 and

Table 1 Summary of comparative specific fuel consumption (kg of fuel/kg of cocoon) data

Unit I			*Unit II*		
Conventional	*Gasifier*	*Difference (%)*	*Conventional*	*Gasifier*	*Difference (%)*
2.18	0.83	61.7	2.06	0.83	59.5
2.13	0.78	63.2	2.10	0.91	56.8
3.33	1.09	67.3	2.38	0.84	59.3
2.78	1.08	61.4	1.70	0.75	55.9
2.68	1.10	58.9	1.81	0.83	53.8
2.65	1.09	59.0	2.00	0.80	58.9
3.09	0.80	74.2	2.12	0.93	56.1
2.38	0.89	62.6	2.24	1.00	55.4
2.45	1.00	59.2	2.13	0.79	62.7
2.45	1.09	55.6	2.13	0.85	59.9
2.53	0.99	60.9	2.21	1.04	53.0
2.63	0.90	65.7	2.08	0.86	58.8
2.68	0.78	70.9	2.06	0.95	53.9
2.47	0.96	61.0	2.03	0.89	64.1
2.92	0.93	68.2	2.06	0.92	55.4
2.64	0.96	63.9	1.83	0.72	60.6
3.20	0.93	70.8	2.06	0.89	57.0
2.60	1.05	59.6	1.92	0.75	60.9
3.27	1.20	63.3	1.82	0.85	53.3
2.73	1.00	63.3	1.89	0.83	53.8
2.70	0.71	73.6	1.94	0.81	58.6
2.88	0.96	66.8	2.00	0.76	62.0
3.00	0.88	70.8	1.86	0.69	62.7
2.93	1.01	65.4	1.94	0.78	60.0
3.10	1.33	57.0	2.11	0.97	53.9
2.58	0.98	62.1	1.86	0.94	49.5
2.94	1.26	57.0	1.81	0.83	54.2
2.44	0.98	60.0	1.97	1.00	49.2
2.83	1.23	56.6	1.89	0.99	47.6
2.63	1.15	56.2	–	–	–
2.60	0.98	62.4	–	–	–
2.79	1.14	59.1	–	–	–
2.75	1.18	57.0	–	–	–
2.09	0.76	63.8	–	–	–
2.84	0.84	70.4	–	–	–
2.14	1.00	53.1	–	–	–
2.15	0.85	60.5	–	–	–
2.03	0.96	52.6	–	–	–
1.98	0.72	63.6	–	–	–
Average					
2.64	0.98	62.5	2.0	0.87	57.6

Table 2 *Z*-test analysis: reduction in specific fuel consumption

Level of significance (%)	*Critical value of Z for one-tailed test*	*Reduction in specific* fuel consumption (%)
95	1.645	59.2
99	2.330	58.8

4.40 kg-silk/100 kg-cocoon were achieved in the case of Units I and II, respectively.

The statistical *Z*-test analysis of all the 82 data points is carried out at 95% and 99% confidence level and the results are given in Table 4. The percentage improvement in silk yield in the gasifier system is 3.9% at 95% confidence level and 3.7% at 99% confidence level. Thus, the improvement is significant and contributes towards enhancing the profitability of the reeling operation.

Cost–benefit analysis of gasifier-based system

The economic analysis of the gasifier-based oven is made on the basis of field testing at Ramanagaram. However, a few important assumptions made in this analysis are listed below.

1 Unit operation : 300 days/year
2 Cocoon processing rate : 100 kg/day
3 Cost of firewood : Re 1/kg
4 Cost of electricity : Rs 1.5/kWh
5 Silk yarn price : Rs 1300/kg
6 Fuel cutting cost (for operation of gasifier-based system) : Rs 150/tonne
7 Premium due to improved silk yarn quality : Rs 20/kg
8 Interest on loan : 20%

Field data considered for economic analysis

In the present analysis, the following data based on field testing of gasifier system at Ramanagaram has been considered.

1 Specific fuel consumption: conventional oven : 2.29 kg-fuel/kg-cocoon
2 Specific fuel consumption: gasifier oven : 0.94 kg-fuel/kg-cocoon
3 Improvement in silk yield with gasifier oven (average for 82 data points) : 350 g-silk/100 kg-cocoon

Table 3 Comparative silk yield (kg-silk/100 kg-cocoon) data compiled during field-testing experiments

Unit I			*Unit II*		
Conventional	*Gasifier*	*Difference (%)*	*Conventional*	*Gasifier*	*Difference (%)*
8.73	9.01	3.21	10.69	11.53	7.86
9.67	10.09	4.34	11.62	11.93	2.67
9.89	10.13	2.43	11.84	12.55	6.00
10.00	10.18	1.80	10.46	11.24	7.46
7.62	7.91	3.81	11.43	11.89	4.02
10.15	10.22	0.69	12.07	12.40	2.73
10.40	11.10	6.73	12.17	12.60	3.53
10.43	10.83	3.84	10.85	11.19	3.13
10.89	11.61	6.61	7.80	8.20	5.13
9.44	9.91	4.98	11.54	12.03	4.25
10.70	10.98	2.62	11.51	11.89	3.30
11.10	12.03	8.38	10.70	11.15	4.21
10.55	10.98	4.08	11.45	11.72	2.36
11.28	12.08	7.09	11.30	12.04	6.55
11.55	11.62	0.61	12.05	12.54	4.07
10.36	11.00	6.18	11.43	11.94	4.46
9.22	9.53	3.36	11.22	11.62	3.57
8.62	9.18	6.50	11.21	12.00	7.05
7.78	7.91	1.67	12.24	12.71	3.84
9.68	10.23	5.68	12.19	12.73	4.43
5.97	6.47	8.38	12.08	12.46	3.15
9.53	9.68	1.57	12.78	12.90	0.94
9.84	10.44	6.10	12.14	13.11	7.99
8.15	8.42	3.31	10.88	11.54	6.07
7.23	7.36	1.80	11.15	11.47	2.87
8.76	9.05	3.31	10.79	11.23	4.08
9.95	10.32	3.72	11.81	12.22	3.47
10.15	10.40	2.46	11.90	12.08	1.51
9.60	9.97	3.85	8.85	9.21	4.07
8.51	8.83	3.76	10.38	10.79	3.95
9.55	10.07	5.45	10.56	11.11	5.21
7.47	7.68	2.81	10.69	11.28	5.52
10.02	10.58	5.59	10.88	11.74	7.90
9.87	10.46	5.98	11.92	12.18	2.18
9.02	9.76	8.20	–	–	–
9.74	10.58	8.62	–	–	–
10.51	10.94	4.09	–	–	–
10.65	11.18	4.98	–	–	–
11.81	12.52	6.01	–	–	–
11.52	11.86	2.95	–	–	–
12.00	12.19	1.58	–	–	–
10.64	11.33	6.48	–	–	–
11.24	11.36	1.07	–	–	–
10.77	11.06	2.69	–	–	–
9.56	9.74	1.88	–	–	–
11.11	11.71	5.40	–	–	–
10.36	10.60	2.32	–	–	–
11.02	11.45	3.90	–	–	–
Average					
9.85	10.26	4.22	11.25	11.74	4.40

Table 4 *Z*-test analysis: silk yield improvement

Level of significance (%)	*Critical value of Z for one-tailed test*	*Reduction in specific fuel consumption* (%)
95	1.645	3.9
99	2.330	3.7

Benefits (per day) of gasifier oven over conventional oven

The benefits of shifting from conventional oven to gasifier system are as follows.

Conventional oven

1 Fuelwood consumption per day (229 kg @ Re 1.00) : Rs 229

Gasifier oven

2 Fuel-wood consumption per day (94 kg @ Re 1.00) : Rs 94
3 Saving on fuel (135 kg firewood) (1 – 2) : Rs 135
4 Silk yield improvement (0.350 kg*1300 Rs/kg) : Rs 455
5 Improvement in quality (Rs/kg 20*10.35 kg) : Rs 207
6 Total (3 + 4 + 5) : Rs 797
7 Additional running cost (electricity and diesel) : Rs 30
8 Addition fuelwood cutting cost per day (94 kg*0.15) : Rs 15
9 Actual/net benefits (6 – 7 – 8) per day : Rs 752

Source of finance

For economic analysis, the means of finance for the total system are as follows.

1 User contribution : 50% of the total cost
2 Term loan : 50% of the total cost

The payback of total investment, break-even, and internal rate of return are calculated for two different scenarios. The first scenario is considering only wood-saving benefit. The second scenario is considering both wood-saving and silk yarn yield improvement.

Investment

Capital cost of the system	: Rs 65 000

Annual additional cost of gasifier

Interest on investment (20%)	: Rs 6500
Maintenance	: Rs 1500
Contingency	: Rs 500
Total additional cost of gasifier/year	: Rs 8500

Based on this cost, the payback, break-even, and internal rate of return are calculated. It can be seen from Table 5 that the return on investment comes to 28% with wood saving only and 238% considering all the benefits.

Table 5 Payback, break-even, and internal rate of return under different scenarios for Case I

Item	*Wood saving only*	*Wood saving + Silk improvement*
Payback (no. of days)	1055	126
Break-even (no. of days)	95	16
Return on investment (%)	28	238

Conclusions

A down-draft gasifier system has been successfully developed and field-tested for the silk reeling industry. The main conclusions of the projects are listed below.

1. Need to develop gasifier-based commercial package instead of supplying the gasifier alone.
2. Integration of gasifier system to specific process requirement needs input from the user, design consultants, experts, and the manufacturer.
3. The process of evolution from the lab prototype to the final commercial model, accompanied by field testing, material optimization, and user satisfaction is time consuming.
4. Considerable user training and maintenance support have to be provided and user acceptance can come only after painstaking and sustained interaction.

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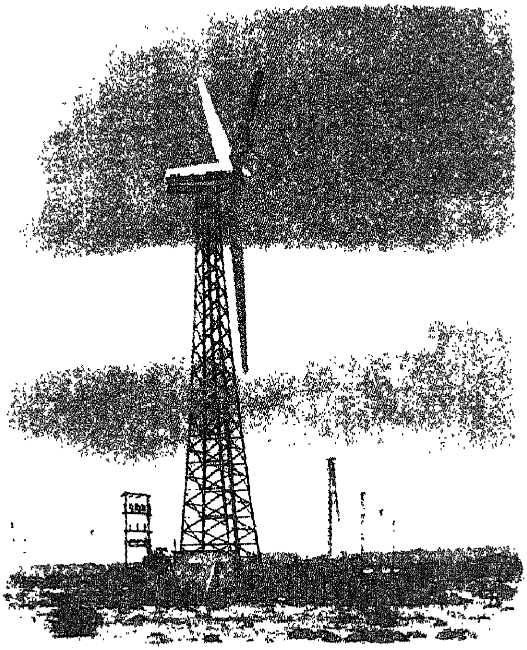

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Synthesis / I-RRB

SDC-TERI experience on product development - case 2: development of simple, low cost, appropriate gasifier system for large cardamom drying in Sikkim

Sanjay Mande and V V N Kishore

Introduction

India is the world's largest producer of large cardamom with an annual production of 4000 tonnes (53.4% of world production). More than 85% of this comes from Sikkim, making it the main cash crop of the state. The moisture content of large cardamom has to be brought down from an initial level of 80%–85% (wet basis) to less than 10% (wet basis) to optimize aroma and preserve it for a long time. The traditional drying process is a primitive and inefficient (operating efficiency level of 5%–15%) smoking method that involved tremendous wastage of fuelwood (estimated 20 000 tonnes a year) and results in a poor quality (charred and blackened) product. Under the ISPS (Indo-Swiss Project Sikkim), TERI has successfully developed and field-tested a simple, low-cost updraft gasifier system suitable for drying large cardamom in Sikkim. The salient features of the system include easy transportability in hilly areas, operation without electricity in remote jungles, and a simple and appropriate system design for ease of fabrication in rural workshops. The present paper gives a detailed account of TERI's developmental efforts from the concept to a user-friendly acceptable product and a summary of field performance results.

Traditional *bhatti* system

The traditional *bhatti* consists of a thick stone/rock wall structure with a large opening on one side for burning logs of wood (Figure 1) while the cardamom is loaded as a thick bed on a wiremesh/bamboo-mat platform. This primitive, inefficient smoking technique consumes an immense quantity of fuelwood and results in poor-quality dried cardamom if the wood is wet.

Detailed energy audits carried out on existing traditional *bhattis* indicate that they operate with poor thermal efficiencies of the order of 5%–15% resulting in an estimated annual fuelwood wastage of

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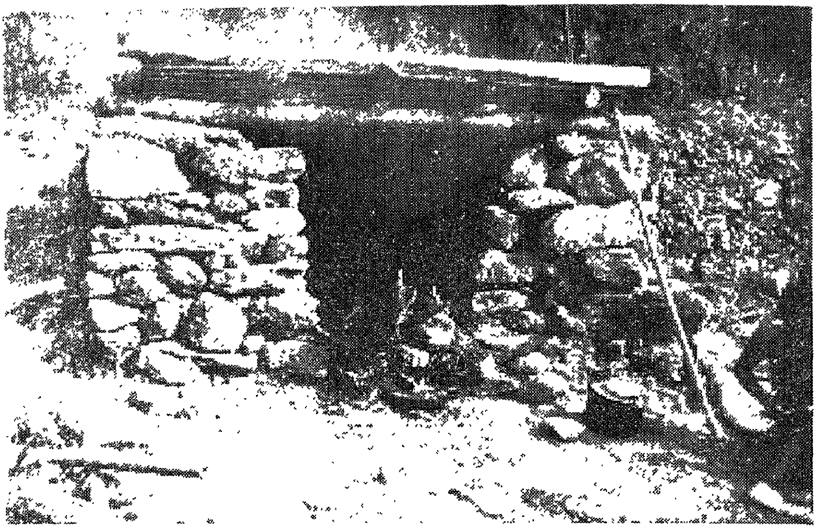

Figure 1 Traditional *bhatti* system for drying large cardamom

approximately 20 000 tonnes in Sikkim alone. The lack of control on *bhatti* fires causes localized heating of the cardamom bed resulting in a charring of capsules and loss of the volatile oil content, which gives dried cardamom its characteristic aroma.

Technological upgradation of the curing method will improve the quality of large cardamom (i.e. maintain its natural reddish colour and volatile oil content) and increase energy efficiency, thereby widening the scope for export at a premium price while preserving Sikkim's natural forests.

Alternative system design

The alternative design should improve performance on two fronts.

1. quality of dried cardamom capsules
2. fuel efficiency.

The use of the simple updraft wood gasifier seems to be the most promising option for the following reasons.

- better conversion (solid to gas) efficiency (above 70%)
- better control on burning (handling gaseous fuel)
- production of clean flue gases (as gas is burnt).

In view of the extensive annual use of the *bhatti*, and the conditions prevailing in hilly sites, any alternative design should

- utilize locally available material to the maximum possible extent
- minimize the incremental cost of the system.

The low-cost updraft wood gasifier system operating on natural draft mode is the appropriate technology for incorporation into cardamom-curing chambers.

Gasifier system for drying large cardamom

Proof of concept: development of 'Mark 0' prototype unit

In northern India, an oven called the *tandoor* is used to make *rotis* (Indian bread). The *tandoor* is a simple furnace comprising a fired earthern pot inside an empty oil barrel. The annular space between the earthern pot and the drum (barrel) is filled with a mixture of ash, stone chips, glass chips, etc. that acts as insulation and prevents the earthern pot from cracking due to thermal expansion and contraction (on heating and cooling respectively).

Preliminary trials on the possibility of using the *tandoor* as an updraft gasifier were undertaken at TERI's Gual Pahari campus (approximately 32 km from Delhi on the Gurgaon–Faridabad Road) in Haryana. An arrangement was made to burn the producer gas on top of the *tandoor* while a small rectangular air inlet with a damper was provided at the bottom to supply a controlled (insufficient) quantity of air required to achieve gasification. The flame of the producer gas obtained through the use of the *tandoor* as an updraft gasifier is shown in Figure 2. Figure 3 shows the gasifier in operation along with a cabinet tray dryer at the Gual Pahari campus.

The oval shape of the combustion volume (maximum diameter at the middle which reduces gradually on both sides) in the existing *tandoor* results in an inadequate fuel storage space. Moreover, a better insulating material such as a high temperature refractory would help in maintaining a higher fuel bed temperature in the combustion zone, enhancing the performance of the *tandoor* as a gasifier. Thus, a modified simple updraft gasifier was made at TERI's Gual Pahari campus by lining a used oil drum with 2" thick castable supercrete insulating material. Several trial runs were carried out with this updraft gasifier to ensure production of sufficient producer gas for drying large cardamom. By controlling the position of the input air supply damper, the burning rate was maintained at 10–15 kg/h, yielding 25–40 Nm^3/h of producer gas.

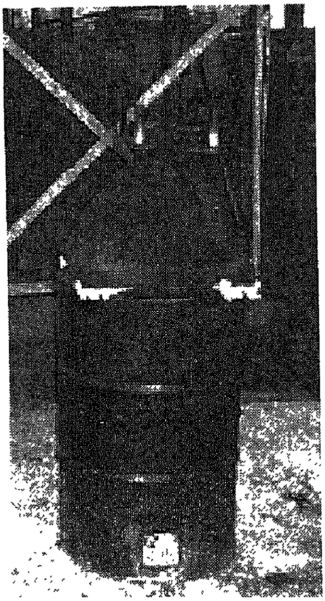

Figure 2 Flame of producer gas obtained using *tandoor* on updraft gasifier

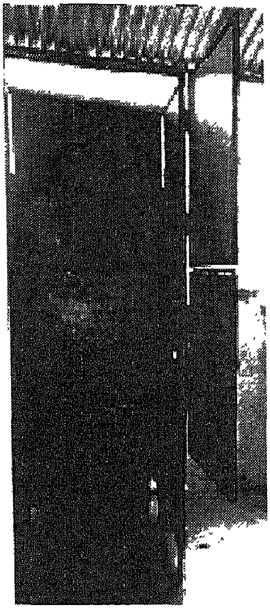

Figure 3 'Mark 0' gasifier system along with cabinet tray dryer

One unit was installed (Figure 4) at Kabi in North Sikkim to receive feedback of the system performance in field conditions. The system was operated for drying 5 batches of large cardamom. Fuelwood saving of more than 50% was observed and there were clear indications of quality improvement in the dried cardamom—retention of its natural reddish colour and increased quantity of volatile oil.

The major suggestions/feedback received during the field-testing of 'Mark 0' prototype unit at Kabi are as follows.

- Locating the gasifier inside the *bhatti* exposes the cardamom bed to smoke, specially during fuel charging or during an unstable flame operation at the start.
- Although the duct helps remove smoke from the *bhatti*, its narrowness impedes fuel charging.
- A person needs to step inside the *bhatti* to charge wood pieces into the gasifier and risks exposure to this smoke in case the flame is extinguished. This was a critical issue since the producer gas contains CO (carbon monoxide).

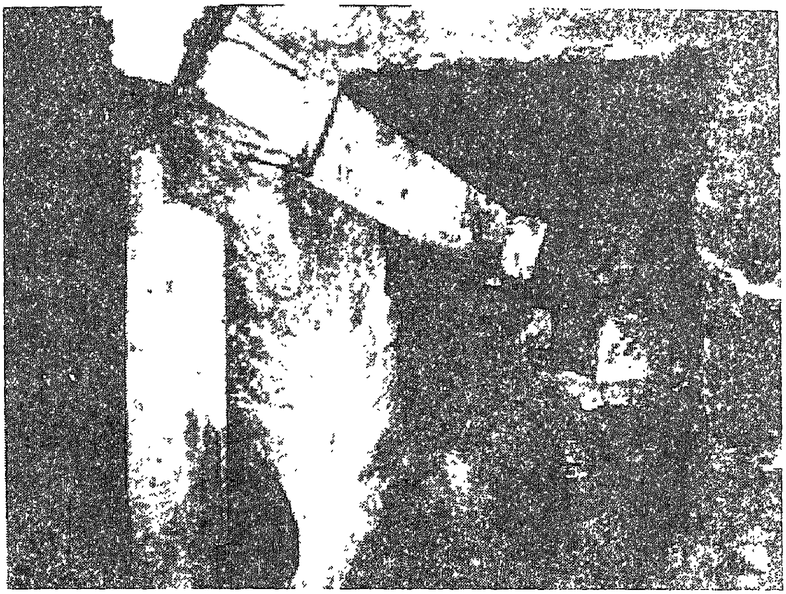

Figure 4 'Mark 0' gasifier system in operation at Kabi

- The entire casting of the 'Mark 0' prototype unit was done in situ and weighed more than 150 kg. The system thus is very bulky and difficult to transport.

Development of 'Mark 1' prototype unit for extended field-testing

In view of the above points, several modifications were incorporated into the system design to make it user-friendly. These are described below in detail.

System configuration

Configuration of the system layout was changed by keeping the gasifier out of the *bhatti* and ducting the producer gas to the burner located below the cardamom bed. This proved advantageous because

- the smoke is kept away from the *bhatti* and hence escapes contact with the cardamom capsules, improving colour retention
- it provides scope for improving the fuel charging component of the system, to make it easier to operate and appropriate for larger pieces of wood
- farmers have the option of enlarging the gasifier size in the future.

Producer gas burner design

Burner designs tried with dry fuelwood pieces included

1. simple square duct (gave very high burning rates and inconsistent but good quality flame)
2. single square open burner with a central air pipe (still gave inconsistent and smoky burning)
3. Venturi burner (provided better flame stability but required a higher roof space and was thus difficult to accommodate in the existing *bhatti*).
4. square burner with multiple small ports.

The first two options yielded very high burning rates and an inconsistent flame with a smoky operation. A Venturi burner could accommodate minor fluctuations in gas quality and provided a stable flame but required a high roof space making the burner difficult to accommodate in the existing *bhatti*. Therefore, it was decided to implement the square burner with a plate of multiple ports. Several trial runs made it possible to arrive at the number of holes and total port area for a given system layout (burner located 2–3 metres away from the gasifier) and the desired fuel burning rates of 10–15 kg/h.

Fuel-charging mechanism

The priorities in developing fuel-charging mechanism were

- to make it easy and quick to operate
- to enable use of larger wood pieces.

Accordingly, the system design was modified with a 12" × 12" square door operated with a simple lever mechanism. A schematic diagram of the fuel-charging mechanism is shown in Figure 5. The system can now take 10"–12" long wood pieces as against 4"–6" in the earlier prototype design. Thus, as for domestic use, farmers can make piles of dry cut wood of 10"–12" length (in contrast to the current length of 18"). No extra cutting will be required if this is done by cutting wet wood in shorter logs while making the pile.

In the improved system, the operator need not open the screws to operate the fuel-charging door—only a lever is used. The door gets converted into a hopper shape on being opened, making fuel-charging quite simple and fast. Valves (dampers) are provided in the duct carrying the gas to the burner and also in the entrance to the

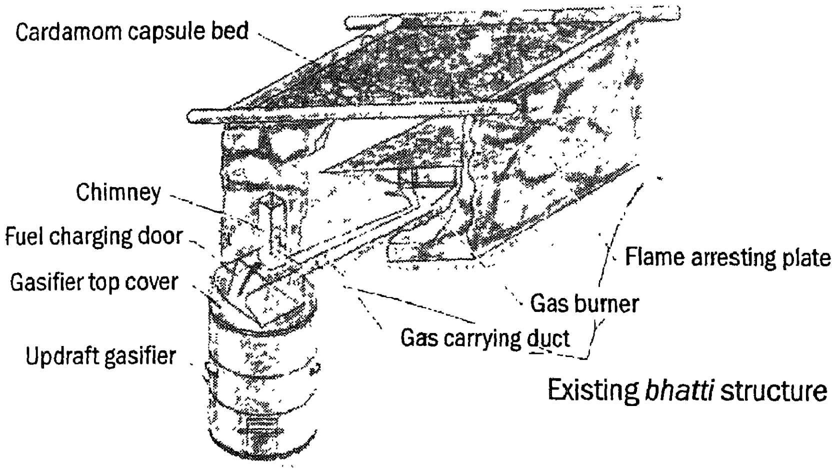

Figure 5 'Mark 1' prototype unit for extended field-testing

chimney. This keeps the gas away from the cardamom bed. The operator has to merely close the gas outlet valve and open the top chimney valve during charging or ignition.

Gasifier insulation

In the earlier prototype, gasifier insulation was done in situ using castable firecrete insulation material. The entire insulation became an integral part of the gasifier (oil barrel), making it bulky and heavy for transportation.

The objectives of developmental efforts, therefore, were oriented towards

- using low cost insulating material to reduce system cost
- minimizing the system weight to make it transportable.

Several grades of castable insulation were tried in the gasifier and finally ordinary grade firecrete insulating material was chosen. This withstands about 1200 °C temperature and costs around Rs 9/kg, thus helping to reduce the cost of insulation by about 50%. In the earlier prototype, ACC Supercrete Whyteheat brand material was used, which withstands up to 1650 °C and costs Rs 21/kg.

In order to make the system transportable, insulation was made in 2 castable rings of 1" thickness, rendering the weight of each individual insulation ring within transportable limit.

Feedback from farmers during field-testing of 'Mark 1' unit

During the course of extensive field-testing, the system operation of several batches of the Mark 1 prototype unit was monitored round the clock in all four districts of Sikkim. Another major objective of such monitoring was to acquire the much-needed feedback from the users (farmers/operators) of the system to improvise a user-friendly and universally acceptable system design.

Technically, the 'Mark 1' system performed very well, providing substantial improvement in the quality of dried cardamom and confirmed fuelwood saving potential. However, farmers indicated a few minor improvements in design and the incorporation of more operational and maintenance convenience factors.

The feedback received from the farmers is summarized below.

- It was difficult to make/keep the fuel-charging door leakproof during system operation. The use of damaged/burnt gland rope to seal the door caused gas leakage from the edges.
- Some farmers said that during the round-the-clock operation of the system, especially in late night hours, a strict adherence to 1.5–2 fuel-charging intervals was difficult. Missing one fuel-charging cycle could exhaust all the fuel in the gasifier and necessitate restarting of the gasifier. This was not only time-consuming but also required greater attention from the operator.
- A few items in the system, such as gland rope for rendering the door gas-tight and ceramic blanket insulation for insulating the gas-carrying duct, were not easily available. These would be difficult to replace in remote hilly areas.
- Farmers said that all system components should be designed in a much simpler way so that they would not need to be repaired for several years. They felt that the lever mechanism used for locking and unlocking the fuel-charging door of the 'Mark 1' design was far easier to use than the earlier version but would probably need frequent maintenance due to the presence of several welding joints and hinges.

Development of improved 'Mark 2' system design

After taking into consideration the above feedback, R&D efforts were focused on the following system component design.

Use of water seal for gasifier fuel-charging door

The operational inconveniences in fuel-charging door can be summarized as follows.

- difficulty in making the fuel-charging door leakproof
- local unavailability of gland rope used in the fuel-charging door
- occasional emergence/escape of flames through the fuel-charging door during charging and while locking.

To eliminate these problems, a water seal in the fuel-charging door of the gasifier was a clear choice. Here, water is placed in the annular space with a top cover. The water level is maintained so that it is more than the pressure difference between the inside of the gasifier and the outside. Thus, no gas can escape through the water seal. This simple principle helps in making the fuel-charging door leakproof while allowing quick opening and closing of the door.

The fuel-charging mechanism with a water seal helped in eliminating gas leakages and reduced the time for fuel-charging. It also gave scope for widening the fuel port, enabling the operator to charge longer pieces of fuelwood smoothly. The only drawback of the system was the need to keep adding water to the water seal to compensate for evaporation. This was further aggravated by the decreasing fuel level inside the gasifier, which exposed the metallic door to the hot fuel bed.

Provision of extended fuel-storage bin

To minimize the problems of frequent addition of 'make up' water and the short interval of fuel-charging, the fuel-storage capacity of the gasifier was extended by using an additional bin. Thus, an open-ended empty barrel was added to the top of the single gasifier design and the water-seal cover was correspondingly moved up. Hence there was less chance of exposure of the top metallic cover to the hot fuel bed and evaporation losses in the water seal were minimized. The 'make up' water now has to be added only at the time of fuel charging, at the increased interval of 6–7 h.

Also, an opening diametrically opposite the gasifier outlet was provided for cleaning the duct with a long rod or bamboo without dismantling the system. The chimney outlet was moved from the sidewall of the connecting piece between the two barrels. The top cover is sized so that it can be placed either on the top barrel or on top of the connecting piece.

Figure 6 shows the components of the improved 'Mark 2' gasifier system with extended fuel storage and water-seal fuel-charging door.

Use of local material for duct insulation

In the earlier system, a ceramic blanket was used as insulation to maintain the high temperature of the gas inside the gas-carrying duct so as to minimize tar condensation. A locally available cane-like material known as *sarkhanda* (*Saccrum munja*) was tried out as a cheaper alternative. First, a thin mud layer was applied on the duct and after wrapping a layer of *sarkhanda* curtain, a second thick mud layer was applied to protect it from direct exposure to fire and to increase its life. Since bamboo is more common in Sikkim, trials were made with bamboo as well.

Modifying the burner design and flare arrester

To improve the uniform distribution of heat across the cardamom bed, a multiple burner system, with one central and four corner burners, was used instead of a single burner system. Figure 7 shows

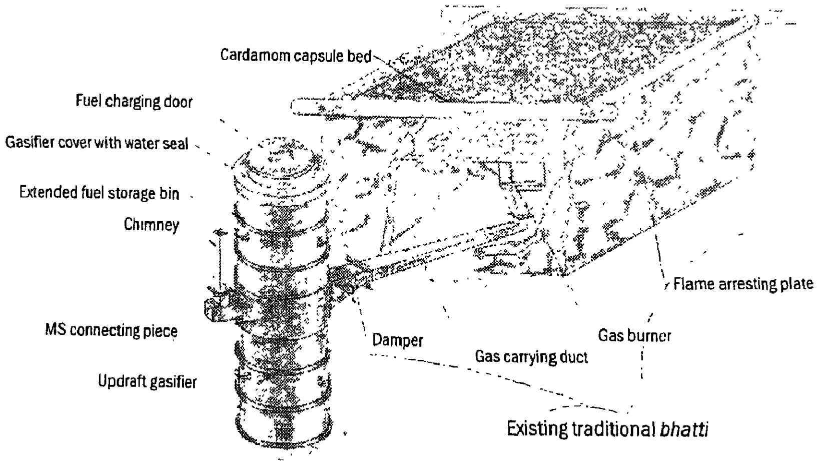

Figure 6 Improved 'Mark 2' prototype unit of pilot-scale plants

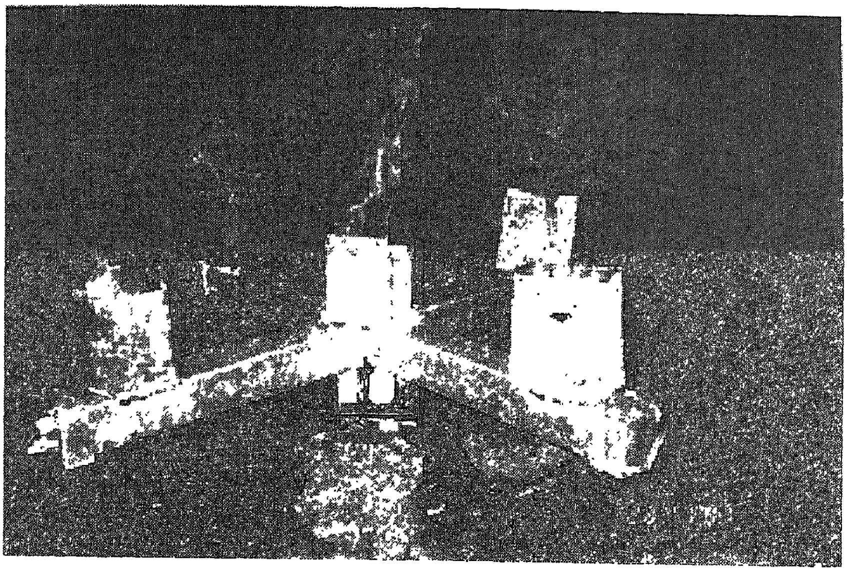

Figure 7 Field-testing of a multiple producer gas burner

the multiple burners operating successfully with the producer gas under natural draft mode in the field.

Field performance of gasifier-based dryer

The developed prototype unit was successfully tested at five field-testing sites in all four districts of Sikkim during the 1996 and 1997 harvesting seasons. Fifteen pilot-scale plants (improved 'Mark 2' unit) were successfully commissioned in North Sikkim during the 1998 harvesting season. To popularize the system in other parts of Sikkim, 30 more systems (10 each in the east, west, and south districts of Sikkim) were field demonstrated during the harvesting season of 1999, with the help of the Horticulture Department, Government of Sikkim.

Performance monitoring of the system in Sikkim proved that the gasifier-based dryer system improves thermal efficiency substantially, resulting in more than 60% fuel saving. The controlled and clean burning of producer gas results in an improved quality of dried cardamom—retaining its natural reddish colour and 35% more volatile oil without a burnt smell (Figure 8). Adaptation of the gasifier-based system has the potential of saving over 16 000 tonnes of fuel annually in Sikkim.

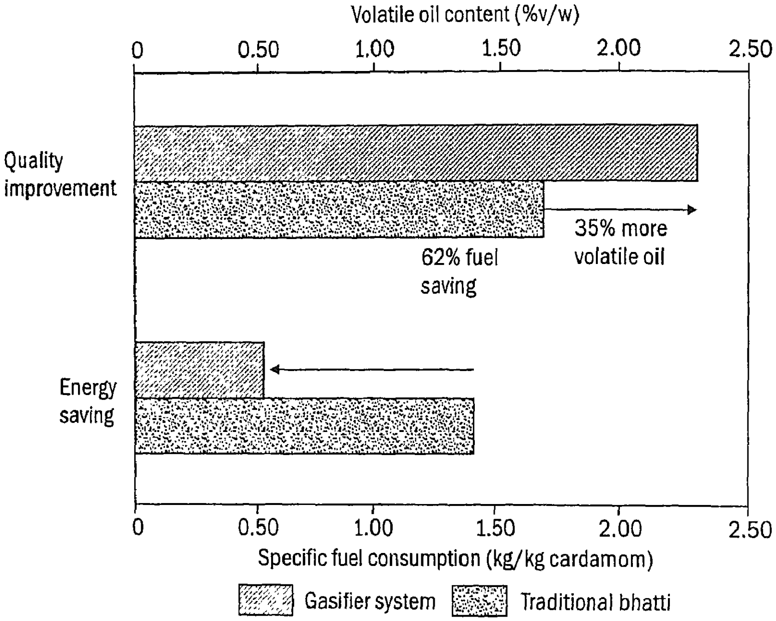

Figure 8 Field performance of gasifier system

Conclusions

An updraft gasifier system operating on natural draft has been successfully developed and field-tested for large cardamom drying in Sikkim. Step-by-step development of this system in the field, after taking into consideration user feedback, has resulted in a simple, low-cost, easy-to-fabricate, user-friendly system suitable for local conditions. Field performance monitoring of the system proved its potential for improving energy efficiency and the quality of dried cardamom.

Acknowledgements

The system described in this paper was developed under a project sponsored by the ISPS and the authors are grateful to them for sponsoring this effort. The support of farmers and the staff of the Horticulture Department, Government of Sikkim, during field activities was crucial for the successful completion of the product development work and the authors are indebted to all of them. The support and encouragement of Dr R K Pachauri, Director, TERI, is gratefully acknowledged.

Renewable energy commercialization

P Venkata Ramana

Introduction

The primary objective of Winrock International India is to promote renewables on a commercial basis. There are large projects of renewables for commercialization through which work is being done towards developing diverse institutional models. Winrock is promoting the commercialization of renewables mainly in the rural areas, and, in the last few years, it has worked towards developing innovative financial packages and capacity-building activities with awareness and creativity.

Apart from the work done in the fields of solar and hydro technology, Winrock has undertaken activities in the sugar industry where it provided technical assistance to large projects, sponsored by the Industrial Development Bank of India, to promote cogeneration in the sugar mills.

Products and markets

The renewable energy programme in India has been problematic for the last 20 years, especially in terms of technology, and has not been much of a success. Renewable energy has never been seen as a successful project especially at the policy level, for many RETs (renewable energy technologies) are still 'programmes' and not moving towards 'products'.

For 20 years, Winrock has been actually doing these programmes, and some of them have gradually moved towards products. It has taken about 20 years to even begin to talk about energy products. Even today at the start of the new millennium renewable energy markets do not exist. Winrock is trying to enter into the conventional markets and start new trends there for RETs. Many of these technologies are largely niche ones. No RET can really be used across the board for various applications. For example, photovoltaic energy

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today is economically feasible only in remotely accessible areas where the grid cannot reach.

Regarding the commercialization of the market, thought is to be given in terms of the framework of the niche market. At the government level, competent officials will never allocate a budget for three years or more for a project, as they lack sufficient finance. Thus, the overall duration for an R&D project is only three years.

For a product to be developed it takes nearly seven or eight years. That is why most of the projects given for three years cannot survive and slowly die out. Though this system has been continuing for over 20 years nobody from the scientific community has put pressure on the government to change this system. Moreover, most of the R&D community is in salaried jobs and not very interested in the activities that could lead to new products, which would contribute to the development of the sector. So, there is no real commitment to product or project development. That is an unfortunate situation. In the last 20 years it has often been said that India has one of the largest renewable energy programmes. If the government had paid a little more attention to these, our achievements could probably have been much larger. The present achievements are very small compared to the overall potential.

Strategies for commercialization of renewables

Streamline promotion strategies

There should not be two different approaches for promotion of the same renewable energy product. For example, at one point of time, the MNES (Ministry of Non-conventional Energy Sources) was providing 50% subsidy for solar photovoltaic products. There was a parallel programme from IREDA (Indian Renewable Energy Development Agency), which was trying to promote solar photovoltaic systems by providing soft loans. Both programmes were targeting the same market but had contradictions in promotion strategies.

Rationalize incentive structure

The incentive structure/subsidies as they exist are a cause for slowdown. There has been an ongoing debate on subsidies. Subsidy is inevitable in many of these technologies. What is relevant is the kind of subsidy or incentives given, and to whom it is given—whether to the user, producer, facilitators, or intermediaries.

Define clear public–private partnership

The renewable energy programme in India has always been promoted by the government, which is one of its limiting factors. There is a need, therefore, to define a public–private partnership for promoting this programme. Some activities are more efficiently done by the private sectors. Renewable energy in the rural areas has been propagated as a cooking or heating paradigm. In fact, most of the renewable energy programmes in India have been promoted for applications in cooking and heating, which are the most productive. We have to link renewable energy with various other applications. Only then will the renewable energy programme be commercialized in the true sense.

Nurture institutional models towards energy service companies

Institutional models are required for promoting these programmes on a commercial basis. Experience in India shows that it is possible to begin energy service companies, which can promote them on a commercial basis.

Take advantage of power sector reforms and climate change initiatives

At the macro level, in order to create more pace and potential in renewable energy one needs to take advantage of all that is happening at the global level. The climate change initiatives in various countries/regions are going to offer major opportunities for renewable energy as a sustainable technology. In India, power sector reforms are taking place rapidly; it will not be long before the private sector becomes entrenched as a provider of electricity. However, in this process of privatization, a large section of people will be left out. Renewables will be a good choice to serve these people. Once the potential of renewables in such areas is explored, commercialization can be appropriately tackled thereafter.

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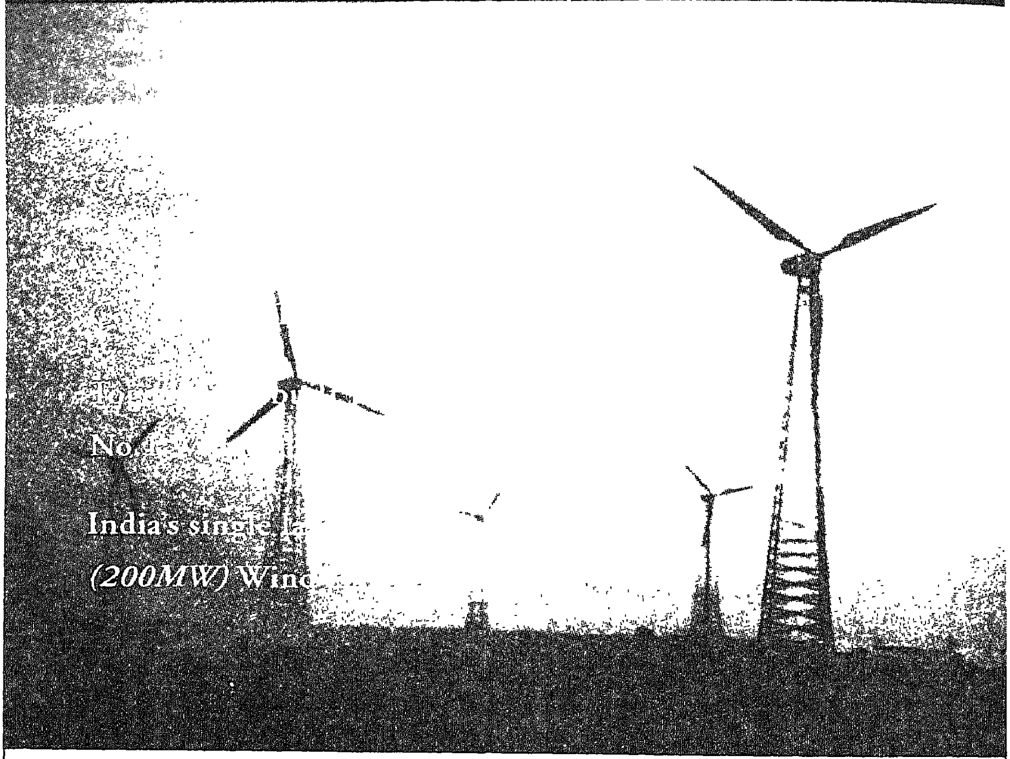

Government Bodies

- Ministry of Non-conventional Energy Sources (MNES)
- Government of Maharashtra
- Maharashtra State Electricity Board (MSEB)
- Indian Renewable Energy Development Agency (IREDA)
- Maharashtra Energy Development Agency (MEDA)

Corporate Clients

- Bajaj Auto Limited
- Ellora Time (Ajanta Clocks)
- Nishkalp Investment
- Bajaj Electricals Limited
- Ghodawat Pan Masala
- Sagar Agencies
- Deccan Industrial Explosive
- Khuda Gawah Investment
- Tata Finance Limited
- Dhariwal Industries (Manikchand)
- Nalini Properties

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Issues and concerns related to product development in renewable energy

V V N Kishore

Introduction

Renewable energy utilization in India has made significant progress since the inception of CASE (Commission of Alternative Energy Sources) in 1981 and the subsequent establishment of the MNES (Ministry of Non-conventional Energy Sources). Several national programmes/projects have been launched so far, but barring a few successes such as solar water heating, wind electric generation, and bagasse cogeneration, renewable energy is largely perceived as a programme 'of the government, by the government, and for the government'. Such a perception stems from the fact that there are not many renewable-energy-based products or packages available in the market for the user. The devices and technologies that are currently marketed are either subsidy- or incentive-driven, and as a result, viable product ranges, strong manufacturing base, and dependable service network are yet to be established. Central to such a scenario is the process of evolution of a commercial product through a complex and sustained interaction among scientists, users, entrepreneurs, funding agencies, and several other players. Though a few sporadic efforts of product development were made in the past, most such efforts were limited to universities and academic institutes, with little participation from users and manufacturers and hence many potential 'product ideas' and prototypes could not be transformed into marketable products.

This paper tries to summarize a few important learning experiences of the author and his colleagues in the past two decades in trying to develop a number of renewable-energy-based products, especially in the areas of solar thermal energy, biomethanation, and biomass gasification.

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Scope of renewables in rural industries

Rural industries or enterprises can be broadly classified into three groups: (1) small and medium industries located in rural areas, (2) agro-based industries, and (3) village industries including those coming under the Khadi and Village Industries Commission. The first group of industries does not necessarily depend on inputs such as raw material, labour, power, and energy from rural areas, but have access to cheaper land and biomass. These industries can gainfully use renewable energy. Some possibilities are:

- solar pond for bromine production, magnesium chloride production, desalination, etc.
- biomass for cooking in industrial canteens, and for power generation
- solar collectors for process heat
- wind electric generators and small hydro systems, where feasible.

The second group consists of agro-based industries such as sugar mills, distilleries, rice mills, manufacture of rice bran oil, cashew processing, tobacco processing, tea processing, plywood industries, and food processing. These industries are crucial to the Indian economy and have a large scope for using renewable energy, which has already made inroads through bagasse cogeneration, biomethanation of spent wash, husk-based power plants, etc. Some future possibilities are:

- small cogeneration systems for tea processing
- solar/biomass-based cold storages for storage of milk, vegetables, fruits, etc.
- solar/biomass-based driers for tobacco, grapes, ginger, turmeric, chillies, etc.
- utilization of wastes through an appropriate technology such as the briquetting—gasification for solids (tobacco dust, herbal waste) and biomethanation for liquid and organic wastes (coffee wastes, press mud, etc.)

The third group of industries consists of very small enterprises such as sericulture, textile dyeing, brick kilns, tile making, fish smoking, cardamom curing, khoya making, soap manufacture, and gur making. Renewable energy devices can be adapted to these enterprises, but the process of adaptation is both expensive and time consuming, as will be discussed later. It should also be possible to promote renewable energy products as rural enterprises; a few examples are listed below.

- Construction and maintenance of biogas plants
- Installation and repair of improved stoves
- Assembling and repair of PV (photovoltaic) systems
- Biomass briquetting
- Making of charcoal-like material through pyrolysis and pelletization
- Running of small power plants as rural energy service companies
- Promotion of low-cost, or 'do-it-yourself' systems such as solar cookers shallow solar ponds, storage type water heaters, and solar stills.

To develop, standardize, and market such diverse and large number of renewable energy products, both the present methods of conducting R&D and the levels of funding seem to be grossly inadequate. It is probably difficult to convey the importance of the need for such an exercise under the present culture of funding renewable energy projects, but it will be helpful to understand some important issues of product development as discussed below.

Dialectics of product evolution

A general confusion prevails in the definition of a product itself. The terms product, process, device, end-use package, system, plant, technology, etc. are used rather loosely in the context of renewable energy.

For example, gasification of biomass can be called as a process. Gasifier is the device or equipment in which the 'process' or the various reactions take place. However, it has little use unless it offers convenience, economic benefits, etc. for a particular user. Thus, a 'gasifier-based silk reeling oven', which integrates the gasifier, blower, piping, cooking basin, burner, flue gas recovery, etc. is a product complete in itself, with a separate niche market (read *SDC–TERI experience on product development – case 1: design, development and field testing of gasifier-based silk reeling oven* by Sunil Dhingra and V V N Kishore, pp. 33–45). It could not have been made by simply 'adding' a device (gasifier) to an end-use (cocoon cooking). It involved 'integration' of the gasifier with the particular end-use of cocoon cooking, which is more complex and time consuming. Complex because it has to conform to various, often conflicting, requirements of cost, space, safety, convenience, life, looks, etc., and time consuming because it has to go through the various phases of prototype development involving users, silk experts, industrial designers, manufacturers, consultants, etc. at appropriate stages (see Figure 4 in *SDC–TERI experience on product development – case 1: design, development and field testing of gasifier-based silk reeling oven* by Sunil Dhingra and V V N Kishore, pp. 33–45). Of course, the degree of complexity and time requirements will vary for different products, but it would be a miracle if a prototype developed in the laboratory automatically transforms itself into a marketable product. The important point is that financial support is seldom available throughout the entire process of product evolution.

The difference between the current practice of funding and a 'desirable' funding pattern is explained in Figure 1. Normally, the funds stop almost abruptly as soon as a laboratory prototype or proof-of-concept system is demonstrated. It is surprising to see that so many individuals in funding agencies and even scientists believe that there is no need to support the process of transformation of a laboratory prototype into an industrial product. It is generally assumed that it is the job of the manufacturer to do this, but the manufacturing base of renewables in India is weak at present and most of the existing manufacturers are only a little bigger than

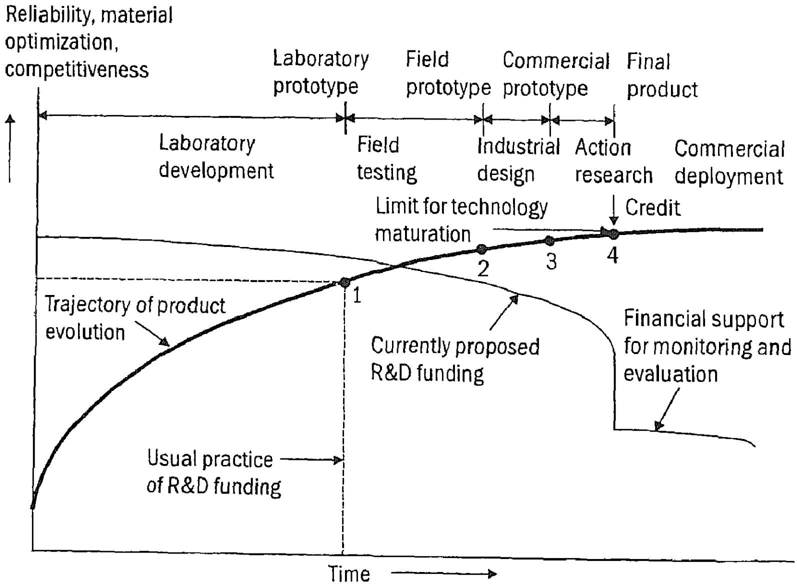
Reliability, material optimization, competitiveness
Laboratory prototype
Field prototype
Commercial prototype
Final product
Laboratory development
Field testing
Industrial design
Action research
Commercial deployment
Limit for technology maturation
Credit
1
2
3
4
Trajectory of product evolution
Currently proposed R&D funding
Financial support for monitoring and evaluation
Usual practice of R&D funding
Time

Figure 1 Trajectory of indigenous technology development

fabricators. Very few have a corporate culture—some just assemble systems and most of them are just one-man outfits. It would be wrong to expect the necessary design, scientific and financial inputs equivalent to those of corporate R&D from these manufacturers. Hence, it is absolutely essential for funding agencies to support the transformation of a prototype into a marketable product. On the other hand, the viability, user-friendliness, life, etc. of the product keeps improving from stage to stage as shown in Figure 1, until it becomes strong enough to enter and sustain the market environment. Seen from this background, it is easy to visualize why there are no improvements in the various devices 'disseminated' by the MNES, such as solar cookers, biogas plants, and dozens of improved chulhas. In all these cases, the first prototypes were promoted through government agencies using the subsidy mechanism and no inputs were taken either from the users or from competent product developers and consultants to improve upon the product. In fact, there is no mechanism in place at present to launch a renewable energy product into the market without subsidy or incentives.

Marketing is another important issue to be understood during the product development stage itself. Almost any product can be pushed into an artificial 'market' aided by subsidies, but it is an extremely difficult task to market a new product in rural areas and in non-consumer market segment. Identification and selection of manufacturers, ensuring quality control, establishing the chain of linkages both for sales and services, all require financial support, which is not available at present both to the scientist and to the small entrepreneur. Only a few influential individuals, manufacturers of large systems (wind electric generators, high pressure boilers) and large manufacturers of well-established products (PV devices) seem to have obtained the necessary market support in the form of demonstrations, tax benefits, interest subsidies, etc. Thus, while a demonstration project preceded market launching of wind farms, the same did not happen for solar ponds. To understand the difficulty of developing and marketing products in rural and seemingly unviable segments, it is helpful to enumerate difficulties faced on different fronts.

Initial product concept

The 'eureka' of a product idea can come from several sources: from an earlier project, by talking to a professional from a different discipline, from a suggestion by a 'bright' individual in a funding agency (his/her interactions at field level often provide good insights of a much needed product), from a dynamic entrepreneur or from an enlightened user. However, many such product ideas, even if demonstrated successfully, fail to take off at a later stage because of inherent weaknesses in the conceptual product. The period spanning the late seventies and early eighties (essentially the post oil-shock period) witnessed the blooming, and equally sudden extinction of numerous renewable energy products. Experience so far indicates that a strong product comes from one or more of the following:

- a field survey and end-user interaction
- an idea of the potential market
- a wise guess on the economic viability
- an innovator's intuition and the necessary scientific basis for the 'doability'.

Further development of a viable product idea is usually hampered by none other than the funding agency.

Difficulties of mobilizing finance

All funding agencies operate with well-defined, time-bound programmes, which usually have little flexibility. They also have pre-decided thrust areas, national projects, etc. often without goal orientation or specific product/process development. The UNDP (United Nations Development Programme) project on biomethanation of industrial and urban wastes, for example, has no component for R&D or demonstration of innovative process ideas. As a result, though a lot of awareness was generated, the money spent is grossly disproportionate to what has been achieved at the ground level. Hence any product idea falling outside the purview of the ongoing programmes or which does not appeal to the 'manager' of the programme gets no encouragement.

The response of most government funding agencies to a product idea varies from 'no response' to 'luke warm bureaucratic reply' to 'down right rude rejection'.

Funding agencies rarely solicit product/project ideas and even if they do, it is generally to satisfy an official or a statutory requirement. Even if some ideas manage to percolate to the 'active' files of the agency, there is usually no mechanism to evaluate a proposal objectively. Often it is sent to selected experts for evaluation, but it is doubtful if the experts themselves act on the basis of objectivity and not on other, non-scientific considerations. Sometimes the projects cleared by experts are blocked by officials or finance people for reasons ranging from lethargy to personal animosity. It is amazing to see how little objectivity prevails in making a funding decision even among people with top degrees in science and engineering. It is common knowledge that the decision to support a project usually comes from a proactive individual within the funding agency 'system'.

Even if the initial project comes through, the funding agency generally loses interest as soon as the laboratory prototype is demonstrated, and seldom supports the transition phase to commercial prototype as mentioned before. In a few cases, where a product idea reaches the field demonstration stage, new problems arise, usually due to conflicts among traditional practices, new product ideas, and perceived benefits of the product.

Shaping the viability of a product through field-level interactions

For field demonstration or testing, selection of a user and site is usually not too difficult, as there is no commitment from the user. However, experience indicates that user selection could be very tricky. Sometimes the user is selected because he is related or known to someone in the implementing or facilitating agency, in which case the user can turn out to be at best a disinterested spectator, who loses interest after a few trials of the system. Several gasifier systems installed under 90% subsidy programme, solar water heaters installed in government buildings, biogas plants installed for rich households, all had problems of disuse later as the user selection was wrong. User for demonstration phase should be selected based on two criteria: (1) he must be either an immediate stakeholder or a future buyer of the system and (2) he must represent a group of the more progressive and enlightened users. While the second criterion is based on a wise and informed guess, the first criterion is not too difficult to meet and might involve some amount of interaction. During the demonstration phase of the SDC (Swiss Agency for Development and Cooperation) sericulture project written agreements have been made between TERI and the user to the effect that the user will ultimately pay some amount or else TERI will have the right to move the system to some other site. The users did pay a depreciation-adjusted cost at the end of the testing phase and gave extremely useful inputs for product improvement.

It is difficult to elicit user reactions to the usefulness or otherwise of the product. After the initial trials, the user will either consistently refuse to make use of the system, or at best will sparingly use it. Only persistent and detailed questioning will bring out the reasons for not using the system. These responses will come intermittently, after long intervals and at unexpected places. A farmer in Sikkim, who successfully used the gasifier for curing cardamom and who appeared quite satisfied with the new product, gave totally negative remarks during an interaction meeting with government officials. In any case, the user never abandons the equivalent traditional system completely. But it is the observant user who also points out benefits not perceived by the developer earlier. The higher yield and better quality of silk yarn for the gasifier-based silk reeling oven, the importance of smokelessness in the populated areas for the gasifier-based dyeing units, the utility and convenience of making charcoal in the same gasifier in Sikkim, the eminent suitability of briquetted biomass char for use in the Hara in a Haryana village, and numerous other unforeseen positive attributes of the new devices or products came out only after frequent and prolonged interactions with the users. But such interactions also throw unexpected and seemingly unsolvable challenges for the scientist or product developer. It is useful to narrate a few examples here.

While the TERI team was working on the development of the spherical biogas plant model, the farmers consistently kept complaining about slurry entering the gas pipelines in winters in many plants. Simplistic measures such as reducing the slurry level in the outlet task did not result in a satisfactory resolution of the problem. Ultimately, the dimensions had to be completely reworked with the help of an optimization model to solve the problem unambiguously. After more than 15 years of the nation-wide launching of the Deenbandhu model of biogas plant, this problem still exists in this model.

In yet another instance, women in a few families consistently refused to use the biogas stoves for baking rotis in Dhanawas. Finally, a trial run supervised by the TERI team, in which one woman made rotis in the traditional chulha and the other woman competed by making rotis on the biogas stove at the same time, proved that roti making is much faster on the traditional stove with the traditional method of 'rolling' the roti in and out of the chulha. Subsequent calculations showed that the power of the biogas stove is much lower than that of the traditional stove. The team could never find a solution for this. Some other women, for example, changed their cooking style and made thinner rotis on their biogas stoves.

During the field testing of gasifiers for cardamom curing in Sikkim, several peculiar problems related to logistics, operation, etc. cropped up. One of the problems was that the gasifier was too heavy to be carried to remote curing sites in the hilly terrains, where the only mode of carrying is on the backs of men. Only several months of struggle and trials in the workshop for alternatives finally gave the answer in the form of two or three separate rings of fireclay insulation, which can be carried separately and assembled at the site.

The important point to be made here is that the team of scientists or product developers have to spend long hours in the field side by side with the users and operators in order to assimilate their experiences and integrate those into the next model of the prototype. Sometimes the team can arrive at the solution by themselves, and sometimes they may require help from others such as professionals from other disciplines, consultants, etc. It is important to use such people in what can be termed as 'competence pooling' at the field testing stage itself in order to avoid certain rejection of the product by the user.

During the field testing stage of the gasifier-based silk reeling oven, the team benefited extensively from the advice of an industrial design engineer (Prof. Bapat of the Indian Institute ofTechnology, Bombay). He filmed the entire process of operation including start-up, manipulation of valves for air and gas control and the procedures followed for daily and weekly cleaning of the system as a part of maintenance schedule. He went back, analysed the various maneuvers and came out with startling deficiencies of the product, which would never have occurred to the team. Inputs like this sharpened the problem-solving skills of the team and at the same time enabled them to translate different concerns and requirements into product re-constitution, with highly satisfying results. Once an industrial prototype is ready to be launched in the market, a new set of players with different concerns enter the picture. In many ways, manufacturer development, establishing a chain for sales and services, diversifying the product into other related sectors, etc. are much more difficult to achieve than product development. However, the original product developers, design engineers, and users will have to play a lesser, but continued role during the marketing phase also in order to fine-tune the product and to expand the user base. This is not covered here due to space constraints.

Conclusions

To summarize, the evolution of a viable renewable energy product is a process that involves careful study and resolution of the various conflicts arising out of concerns and requirements of the user (convenience, cost, life, etc.), funding agency (time over-run, cost overrun), design engineer (safety, elegance, marketability, etc). and the product developers (credibility, continued financial support, sense of achievement, etc.). Ignoring such a process and trying to push unviable and imperfect products through subsidies and financial incentives into artificial markets will be a major barrier in realizing the full potential of renewable energy.

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Development and implementation of the non-fossil fuel obligation in the UK

Garry M Staunton

Introduction

The UK government has been supporting renewable energy and other novel energy systems since the mid-1970s, first under the aegis of the Department of Energy and recently under the Department of Trade and Industry. Over this period, renewable energy technologies have evolved and matured, and the more advanced ones have made a significant contribution to energy supply in the UK, accounting for 2.8% of the nation's electricity in 1998. The distinct potential for further deployment could play an important role in the efforts to reduce the environmental effects of energy supply and use.

The UK has a 10-point strategy for renewable energy, which is intended to deliver 5% of the nation's electricity from renewables by 2003 and 10% by 2010. A number of interlinked initiatives are intended to deliver this increased contribution. These include research, development, demonstration, and dissemination programmes that are linked to a market stimulation initiative which will build on the successes of the NFFO (non-fossil-fuel obligation).

This paper briefly discusses the background position of renewable energy in the UK and explores how support for renewables has responded to the changing technical and commercial challenges that have influenced the technologies as they matured. In doing this, it concentrates on how the NFFO market enablement mechanism operates and how this has emerged as a highly successful support mechanism.

Background

It is being increasingly recognized that energy supplied from renewable energy sources has a number of benefits.

- *Environmental benefits* Renewable energy technologies typically have relatively low environmental impacts, and in their operation

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they produce little or no net emission of polluting gases such as carbon dioxide and other greenhouse gases.

- *Energy and economic benefits* These benefits are evident, particularly in less well-developed economies where renewable energy technologies stimulate development by offering a greater diversity of supply (using local resources rather than imports) and where their speedy construction and modular nature may match local needs.
- *Trade and competitiveness* Renewable energy technologies rely on local and national resources, thereby reducing the need for imports. Hence, they can reduce exposure to international instability and contribute to the security and diversity of energy supply. The growing scope for renewables also presents significant business opportunities. The European Commission estimated that the annual world market for renewable energy equipment in 1990 amounted to around 50 billion dollars—a figure that has already increased, and will continue to increase. The WEC (World Energy Council) has predicted that by 2010 the total global market for renewables could be 250–500 billion dollars.

At the same time, renewable energy technologies face a number of barriers that must be overcome before these technologies can take their place in the market. These barriers may be placed under four broad categories.

1. *Social/environmental barriers* A lack of experience in complying with planning regulations and gaining of public acceptance strongly influences market penetration.
2. *Technical barriers* There is a need to further improve technical and financial performance in such areas as conversion efficiency, reliability, and integration into the grid.
3. *Economic barriers* These are factors that affect the prices obtainable for renewable energy and for competing with other sources of energy, including the treatment of external costs, the allocation of subsidies, and high transaction costs.
4. *Institutional and legislative barriers* These are factors that hinder the market penetration of technologies that are economically competitive (e.g. lack of information and/or awareness, inappropriate standards, legislative obstacles, excessive risk weighing of capital).

Against this backdrop, a number of international studies reflect an increasing confidence that renewables will meet a growing proportion of world's energy demand.

- Under 'trends continued' scenarios, the WEC estimates that by 2020 the contribution of renewables (including traditional biomass and large-scale hydro) to total primary energy supply could rise from 18% to 21%. Under 'greener' scenarios the estimate rises to nearly 30%.
- A United Nations report indicates that by 2050, renewable sources of energy could account for 60% of the world's electricity market and 40% of the market for fuels for direct use.
- Shell International has published scenario-based projections, which attribute 40% of the total energy supply in 2060 to (modern) biomass, solar, and wind.
- Recognition of the significant contribution that renewable energy could make to worldwide economic growth, particularly in developing countries, has been documented by a number of agencies such as the World Bank.

Support for renewables in the UK

Introduction

The UK government has held programmes in support of renewables, which have aimed at evaluating, developing, and encouraging commercialization in the field of renewable energy and other novel energy sources for over 20 years. Initially, the programme conducted by the Department of Energy concentrated on assessing the feasibility of renewables, the potential contribution to the UK energy supplies, and the costs and timing of such contributions. This led to a programme of R&D, carried out in collaboration with the industry and aimed at improving the basis of the early assessments and at advancing the technologies. In 1990, as part of the changes in legislation associated with privatization of the UK electricity industry, renewables were included in the NFFO. This provided an incentive and route for the commercialization and deployment of better developed electricity-producing technologies.

Since the introduction of the NFFO, there have been regular reviews to assess progress and set priorities for future activities. These reviews have considered, among other things, the state of